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THE DEVELOPMENT OF OUR KNOWLEDGE OF THE LAWS OF FLUID MECHANICS[1]

By Professor W. F. DURAND

STANFORD UNIVERSITY

IN the absence of special thought on the subject, we are little likely to realize the dependence of our every-day life on the laws of fluid mechanics. Thus the air as a fluid is drawn into and expelled from our lungs in accordance with these laws. Again the blood circulates through our arteries and veins under control of the same laws. The gentle zephyr which cools our face in summer or the hurricane which leaves death and destruction in its path are only the expressions of air moving under the laws of fluid mechanics. The trajectory of a golf ball or of the shell from a 16 inch coast defense rifle are likewise the expression of the laws governing the relative motion under gravity of a solid body in a fluid. So again the sustentation of the airship or of the airplane or again the need for the expenditure of energy to secure continued movement through the air: these are all expressions in different ways of these same laws. The same is true of the flotation of a ship partially immersed in water and of the need for propulsive machinery and the expenditure of energy in order to insure continued movement.

Again the entire collectivity of the phenomena of lubrication is only a special expression of the laws of fluid mechanics. So likewise are such divergent phenomena as the rapid spread of sugar through a cup of coffee when we use the spoon as a stirrer, and the carriage by the Colorado River of a burden of silt amounting to something like 5 billion cubic feet per year. In fact, the present configuration of the earth's surface, in so far as wind and water erosion

[1] Presidential address at the meeting of the Pacific Division of the American Association for the Advancement of Science, Salt Lake City, June 12, 1933.

combined with the fluid transport of solid materials have played a part, is the result of the operation of these same laws.

The basic problem of fluid mechanics is this; what is the behavior of the fluid in the case of relative motion between a fluid and a solid, and what system of mutual forces acts between the two under these conditions?

The phenomena involved in the relative motion of a solid and a fluid must have attracted the attention and challenged the curiosity of our prehistoric forebears, but so far as we have any present record, the discussion of these phenomena of nature first took definite form among the Greeks and with special reference to the movement of bodies through the air. The fact of the resistance of the air to such motion was recognized and accepted, apparently without attempt at explanation. The problem, as it took form in the minds of the Greeks, was not, therefore, whence the resistance to motion, but rather why does motion persist against this resistance after the stone has left the hand or the arrow has left the string of the crossbow.

Regarding the speculations of the ancients on these matters, we have little beyond the brief discussion by Aristotle given in section eight of the fourth book of his "Physics." He is here concerned with an attempt to prove the impossibility of the existence of a vacuum. Recognizing the observed resistance to motion both in air and in water and in the absence of any concept of inertia or energy in the modern sense of these terms, the ancients could only conceive of continued motion as the result of the continued application of a propulsive force. Furthermore, it was held that the motion of a body A was only possible as it was pushed or urged by another body B, and the motion of B was in like manner conditioned upon the action of a third body C, and so on indefinitely.

To this general law, projectiles must, of course, be subject, and to the air was assigned the function of supplying the continuing force required to carry the projectile from the body with which it was first in contact until it had reached the target. From this course of reasoning, Aristotle deduced that, without air, the motion of a projectile would not be possible, and hence, as a conclusion, a vacuum could not exist.

As to the manner in which the air could thus operate to supply a propulsive force, Aristotle did not deeply concern himself. He left rather the working out of these details to his successors, suggesting two hypotheses as possible. One of these adduced the action of the air in rushing violently in behind a body in motion, in order to fill the partial vacuum formed, as furnishing the needful push on the rear face of the projectile. The second hypothesis assumed that the air, by reason of its special fluidity, was able, if once put in motion by the body with which the projectile was first in contact (the crossbow, for instance), to continue its motion and its action on the projectile.

In the sixth century A. D. these ideas were opposed by the Greek grammarian Philoponus, who put forward the hypothesis that, when casting a projectile, a certain impetus was transfused into it by the caster, this impetus being then able to maintain the projectile in motion for a certain length of time.

Little progress was made beyond these rival theories until the later formulation of the concepts of inertia, momentum and energy. With these concepts available, however, all controversy regarding such methods of explanation came to an end and the action of the air was recognized as operating continuously in the sense of a resistance rather than as a propulsive agent.

Referring to this transition period, we may note that Leonardo da Vinci, in his earlier discussion of these matters, assumed, in accordance with the Aristotelian physics, the air as assisting the motion of bodies through it. However, at a later period and definitely in 1506, he abandoned these older ideas and recognized in the air a resisting medium, the resistance of which he ascribed to its condensibility, as he termed it. While he apparently recognized that a part of the total resistance was due to dividing the air and putting it in motion, he considered this the minor part and ascribed the major part to the condensation of the air in front of the moving body.

As a result of this same action, Leonardo deduced the explanation of the lift of birds as due to the condensation of the air under the stroke of the wing. He then considered the possibility of human flight, and, as is known, made a number of designs and left a number of notes bearing on the solution of this problem.

It is one of the tragedies of scientific work that these later researches of Leonardo were lost to the world for so many years. He wrote no books and put down the results of his studies in the form of rough notes, comments and sketches in notebook form. Having in view the background of science in his day, much of this work shows him to have been far ahead of his age and in many ways marvelously near the line of later developments. But hidden and unknown as his work was until relatively modern times, it had, as a matter of fact, little or no influence on the general trend of development in the centuries immediately following his period.

We must ascribe to Galileo the first approach to the foundations of our present interpretation of the phenomena and laws of fluid mechanics. In 1632 he devoted a special section of his "Dialogues on Maximum Systems" in opposition to the Aristotelian theory

of the action of the medium, and undertook to demonstrate its action as essentially one of resistance rather than of propulsion. Through the development of his ideas on these matters, and his well-known work on the laws of falling bodies and on pendulums, Galileo, though not always correct in all his conclusions, may most properly be called the father of our modern mechanics.

We must now pass in rapid review some of the great names of the centuries which followed the time of Galileo, with only the briefest of reference to the contributions made by them.

First Huygens, who in the closing years of the seventeenth century announced, as based on experimental evidence, the proportionality of the resistance, in the case of motion through a fluid, to the square of the velocity.

At the same time Newton in his great work on the "Mathematical Principles of Natural Philosophy" (1687) dedicated the whole of the second "book" to the study of what we should now call "fluid mechanics," and in which actual fluids such as water, air, oil and mercury were considered, as well as certain others ideal in character, as defined by special mechanical and physical properties.

Newton recognized that the resistance of a body in motion in a fluid depends on the density of the fluid, on the velocity of motion and on the form of the body. He also recognized the influences of friction and of viscosity as elements in the problem. His broad conclusion was that in the more general case resistance comprises three parts, a first part uniform, a second part proportional to the velocity and a third part proportional to the square of the velocity.

One of Newton's special studies related to the behavior of a hypothetical fluid composed of discrete elastic particles, and it was as a result of the discussion of this ideal medium that he deduced his so-called sine square law—that is, that the action of the fluid on a plane moving obliquely through the fluid is equal to that on the plane at right angles to the direction of relative motion, multiplied by the square of the sine of the angle of incidence. This law gave rise to much controversy. If true, it was shown that aerial flight was not possible. It was soon disproved by experiments carried on by Borda, Dubuat, Hutton and others. Newton has been much criticized in connection with this particular result deduced from his assumption of an artificial fluid medium. It is, however, open to question whether Newton considered this discussion as more than a mathematical exercise. He certainly recognized the artificial and ideal character of the medium assumed, and there seems to be no evidence that he seriously considered these results as applying to actual fluids. In fact, in his scholium commenting on the thirty-fifth proposition, he clearly distinguishes these results from those which pertain to actual or, as he calls them, "continued" fluids, such as water, oil and mercury.

Summing Newton's contributions to this problem, it would appear that he clearly recognized the various factors involved in resistance and that he made some approach to an evaluation of their measure. He also recognized the principle of the relativity of motion—that is, that whether the fluid be considered at rest with the body moving through it or the body at rest with the fluid moving past, the results should be the same, assuming the relative velocities the same.

It is perhaps not too much to say that the contributions of Newton to mechanics in the broader sense and to the beginnings of the branch of mathematics later known as calculus have been, on the whole, more important in the later development of fluid mechanics than his researches on this particular subject. In fact, it is not easy to see now how Newton, with the tools at his disposal, could have made any closely detailed study of fluid motion or of the forces involved between fluids and solids in relative motion. It must be remembered that this was before the concepts of calculus, either as presented by Newton or Leibnitz, had been developed into form suitable for dealing with such problems. In particular, it was before the development of the treatment of problems of continuous change by means of the differential equation, and without the aid of this mathematical discipline it is not easy to see how any effective study could be made of the behavior of continuous fluid media.

However, even with the differential equation, powerful as it is, we are not yet able to cope fully with actual fluids as they exist in nature, and to meet this limitation, the ideal fluid of the mathematician has been substituted for the actual. This fluid is characterized by two special qualities which differentiate it from actual fluids; the absence of viscosity, *i.e.*, perfect fluidity, and incompressibility. As a consequence of the first of these, the fluid possesses infinite mobility; there is no resistance to the sliding of one particle near or past another one.

As a consequence of the second characteristic, incompressibility, no element of the fluid, as a result of changes of pressure incident to relative motion among its parts, experiences change of volume. This is true to a high degree of approximation for liquids, and to this extent such media, for all practical purposes, fulfil this requirement of the perfect fluid. On the other hand, gases and vapors are subject to large changes of volume with change of pressure and hence depart in much greater degree from this requirement of the perfect fluid. However, fortunately for many classes of problems and especially for most of those which present themselves in the domain of aerodynamics in its application to aeronautic engineering,

the changes of pressure incident to the motions with which we are concerned are small in comparison with the total pressures involved, and the resultant changes in volume are relatively small and often negligible, thus permitting a very satisfactory treatment of practical problems on the assumption of a complete fulfilment of this specification of a perfect fluid.

At this point, then, we have the perfect fluid of the mathematician and four principal means for dealing with the problems presented by internal motion among its parts, or by relative motion between the fluid and solid bodies or solid boundaries. These four agencies are (1) the differential equation with collateral mathematical disciplines, (2) a sound and rational development of mechanics, that is, the relations of length, mass, time, force, energy, momentum, etc., (3) conformal transformation, and finally, (4) the concept of sources and sinks.

The first of these came out of the original work of Newton and Leibnitz and is directly based on assumption of continuous change and as such is peculiarly adapted to problems involving continuous changes in time or in space, such as those presented by relative motions of solids and fluids, or among and between adjacent parts of the same fluid.

The second of these, due primarily to Newton and as later elaborated with special reference to fluid mechanics by John and Daniel Bernouilli, D'Alembert, Euler, Lagrange and others, makes possible the correct framing of our differential equations and the proper interpretation of their results. Of this group, the two Bernouilli's and D'Alembert were more directly concerned with fluid mechanics as such, while the interest of Euler and Lagrange lay rather in the mathematical aspects of the problem. Euler may indeed be called the father of the mathematical expression of the theory of the perfect fluid, while Lagrange carried on the development in further detail, building largely on the foundation which Euler had laid.

The third (conformal transformation), through the wizardry of geometrical relations, makes possible the transformation of results derived for relatively simple forms of boundary between solid and fluid, to others much more complex in their geometrical character.

The fourth makes possible the building up, constructively, of shapes and forms of fluid masses, in either two or three dimensions of space, and around which a field of fluid flow coming from a distant point will divide as though this constructive mass of fluid were a solid body. In fact, the boundary of this constructive mass of fluid bears the same relation to the remainder of the flow as would a solid body of the same form, and hence we may assume such a body substituted for it, thus obtaining the distribution of force reaction over such body when placed in a field of flow, as well as the lines of flow in the fluid in passing around the body.

These various agencies have thus made possible a very considerable development of fluid mechanics as applied to the perfect fluid. The mathematical control of this domain, is not, however, complete, due chiefly to the difficulty of introducing into our differential equations adequate representation of complex geometrical forms, or otherwise, finding, through tedious and complicated methods of trial and approach, the representation of such form through the use of sources and sinks. However, given any case involving a solid body and a perfect fluid in relative motion, and required the distribution of force reaction between the two, together with the stream lines of flow about the body, and given likewise time and patience, it is fair to say that, through the use of these various agencies, a solution to any reasonable degree of approximation may be found.

Over this same general period of growth in theory, covering the latter part of the eighteenth century and the early years of the nineteenth, there developed a gradual accumulation of the facts of experimental research on these various problems, due to the work of D'Alembert, Borda, Dubuat, Bossut, Duchemin, Robins, Vince, Navier, Robinson and others, thus serving as a check and needful guide on the development of theory alone.

Out of this elaboration of the theory of motion in perfect fluids, there came, however, a most surprising and puzzling result. It will be recalled that the resistance to the relative motion of a solid and a fluid had formed one of the chief objects of interest to Newton and to those who followed him. Likewise, the oblique or lateral force manifested in the case of a body of approximately flat or elongated section, when moving obliquely through a fluid, had formed a major subject of interest. Now with means adequate for the investigation of such problems for the case of the assumed perfect fluid, it appeared that there could be no such resistance; or more generally, no over-all force reaction in any direction, and hence no oblique or lateral force.

It should be noted, however, that the relative field motion assumed between the solid and the fluid was rectilinear and unaccelerated. This would correspond to the case of a solid body moving with a uniform velocity in a straight line through an infinite fluid medium; or, on the other hand, to the flow of such an infinite fluid field past the body, with a field velocity uniform and in a straight line.

However, in actual fluids, the fact of resistance, or of over-all force reaction was obvious. It had challenged the attention and interest of all who had concerned themselves with these matters from the time of Aristotle down. It was then obvious that the ex-

planation of the actual and observed over-all force reactions must be found, either in those circumstances which differentiate actual fluids from the medium known as the perfect fluid, or in departures, in the case of actual fluids, from the simplicity of field motion which had been hitherto assumed. As we shall directly see, both of these differences play their part in furnishing the final explanation.

Before passing to some consideration of this final explanation (at least as now received) brief note should be taken of the experimental researches as well as of the developments in theory which laid the foundation for the solution of the problem.

Of the two characteristics of actual fluids, omitted by mathematical necessity in forming the specifications for the perfect fluid, that of viscosity was recognized from the first as the more important of the two, and indeed as accountable presumably in primary degree for the observed differences between the results for actual fluids and those indicated by theory for the perfect fluid.

If we come now to a period near the middle of the last century, we find the beginning of serious and effective studies relating to viscous fluid media. Among these early writers note may be made of Coulomb, Duchemin, Poisson, Barré de Saint-Venant, and between 1845 and 1856, Stokes, who, in a series of brilliant papers, laid a broad foundation for later studies on this subject. To this same period belong the experiments of Poiseuille (1840–42) which, a few years later, served as a starting point for the brilliant researches of Osborne Reynolds. To Reynolds we are indebted for the definition of the two modes of flow, laminar and turbulent, to the definition of the non-dimensional function of length, velocity, density and viscosity which has properly received the name of "Reynolds Number," and of defining the value of this number which marks the zone of change between these two modes of flow. It would not be easy to point to another single contribution to the theory of fluid mechanics which has exercised a more profound and far-reaching influence on the later studies in this domain, lying as it does at the foundation of the application of the laws of kinematic similitude to the problems of fluid movement, and hence standing as the justification of the enormous extension of model research in recent years to the problems of hydraulics, to those of shipbuilding, of aeronautics and to practically all phases of the problems of fluid mechanics as they bear on the problems of actual life.

To this same general period belong also the epoch-making researches of Helmholtz (1821–1894). To his contributions must be credited the most notable advance in the theory of fluid mechanics since the days of D'Alembert, Euler and Lagrange.

While he illuminated many phases of fluid mechanics, his most notable contributions related to the study of vortex motions in fluid media and to the existence of what he termed surfaces of discontinuity between zones of fluid moving under different physical conditions. With his paper on vortex motions, Helmholtz opened a new field of research, which, carried on in more recent years, has yielded epoch-making changes in our concept of the dynamic relations between solids and fluids in relative motion, and has shed a flood of light on the source of the various force reactions between the fluid medium and the solid bodies.

Again the existence of surfaces of discontinuity in fluid flow was used by Kirchhoff (1869) and by Rayleigh (1876) as a foundation for an explanation of the resistance to the motion of a plane moving through a fluid, a result which, as we have seen, the classical theory had completely failed to explain. Not only was this problem treated in a qualitative sense, but formulae were deduced by Kirchhoff for the case of a plane moving in a direction normal to itself, while Rayleigh independently and later deduced formulae for both the cases of direct and of oblique motion.

It may be remarked at this point that later researches and developments of what may be called the Prandtl school have furnished a more satisfying explanation of the force reaction between solids and fluids in relative motion and a more accurate basis for its evaluation. However, these latest developments go back, for their foundation, to the laws of vortex motion, and hence, in any case, we may ascribe to Helmholtz the credit of laying the foundation for these most recent advances in the explanation and quantitative determination of the force reactions in the case of the relative motion of fluids and solids.

We may now pass to those advances which have especially characterized the present century, and inasmuch as these have centered largely about the problem of the airplane, they may be considered primarily from this point of view. The major problems are here three or perhaps four in number: (1) The source of the lift on the wing of an airplane and its quantitative measure; (2) the source of the resistance to motion and its quantitative measure; (3) the rôle played by viscosity as a factor in problems (1) and (2); (4) the same query with regard to the compressibility of air viewed as an elastic and compressible medium.

As we have seen, the classical theory based on an assumed ideal or perfect fluid gave no explanation of either lift or resistance, and, for rectilinear unaccelerated motion, it gave definitely zero force reaction in all directions between a solid and a fluid in

relative motion. The first step forward was taken independently by Kutta in Germany and Joukowski in Russia, who showed that, even with the perfect fluid of the mathematician, assuming a special form of vortex or circular motion in the fluid about the body, combined with the rectilinear motion, a lift would result in a direction at right angles to the line of rectilinear motion. And further, for the measure of this lift, an astonishingly simple and elegant formula was developed.

The term "circulation" has been applied to the line integral of the velocity taken in any path completely around the body. This means simply that if any line, a circle for example, be circumscribed about the body, then the circulation is measured by the summation of all the small elements formed by multiplying each element of length of the path by the velocity along the path at that point. Then the particular type of vortex motion assumed is such that the circulation in all paths about the body remains the same. The formula for the lift is then given simply by the product of the circulation, by the velocity of rectilinear motion and by the density of the fluid.

This law is commonly known as the Kutta-Joukowski law, from the names of its two discoverers, each working independently of the other. The justification for the assumption of this particular law of vortex motion develops from the mathematical theory of potential motion in a perfect fluid and is entirely consistent with the conditions for such motion in such a medium. It is thus seen that the explanation of lateral force, or of lift in the case of an airplane, was developed as a result of superimposing, in a perfect fluid, a special form of vortex or circular motion on the rectilinear field motion which had been hitherto assumed in dealing with such problems.

But while the combination of circulation with rectilinear motion explained lift, it was recognized that there still remained the problem of explaining the explanation. That is, there is no way, in theory at least, of initiating such a form of vortex motion in a perfect fluid devoid of such motion at the start.

However, before proceeding with the discussion of these terminal problems of lift and resistance, we must consider a little more closely the surface and near-by phenomena attendant on the relative motion of a solid body and a viscous fluid. The non-viscous fluid, it will be remembered, is defined as one in which the ultimate particles in gliding or sliding past each other exercise no mutual force reaction. As we must deal with them, all fluids are viscous in varying degrees. Again, the manifestation of viscosity depends in profound degree on the relative velocity of motion. Thus, for very slow motion, certain substances like resin exhibit the phenomena of viscous flow and from such extremes the condition appears continuously in decreasing degree down through such fluids as tar, oil, water and on to and through vapors and gases. Thus, air in popular estimation would not be considered a viscous substance; but it is distinctly so, and where the relative velocity of gliding (or shearing, to use the more technical term) is great, these viscous drags exercise a controlling influence over the attendant phenomena.

It has only become possible, through the aid of modern atomic theory, to form some picture of how and where these drag forces originate. Apparently, we must look for their source in the stray electric fields surrounding the molecules of the fluid and due to the special electronic architecture of the molecule. In any event, the result of these mutual viscous drags acting on two molecules in gliding motion past each other is to impress upon them some degree of rotary or spinning motion. In the case of the non-viscous fluid under the so-called "potential motion", the ultimate particles are assumed to move without any such rotary motion, and, as it develops, this results in a great simplification in the mathematical aspects of the problems of fluid motion.

A point of the highest interest in connection with the phenomena of the relative motion of a solid and a viscous fluid is that a very thin layer of the fluid, perhaps only one molecule thick, is bound to the body and moves with it (supposing, for simplicity, the case of a solid moving in a fluid considered otherwise at rest). Then, passing outward from the body, there develops a continuous lagging of the successive layers of fluid particles, until finally, at some little distance from the body, the effect of these drag forces decreases to the point of vanishing.

We have thus the picture of a continuous series of layers of particles outlying from the body with relative motion between, the result of which is a condition of more or less irregular spinning or vortex motion, throwing the fluid into a state of mixed turbulence quite beyond the reach of mathematical expression in other than some statistical or approximate fashion. Furthermore, this blanket of irregular turbulent fluid of necessity embodies and thereby impounds a certain amount of kinetic energy which streams away to the rear. It is then the continuous generation of this energy which appears manifest as a decrease in the pressure energy of the moving fluid, or broadly as a resistance to the motion.

With this picture, we have, therefore, the body surrounded by a blanket of eddying turbulent fluid, as the physical expression of the action of these minute molecular forces previously referred to. This blanket of fluid is commonly known as the boundary layer, separating, as it does, the solid body from the outlying mass of fluid wherein these effects are negligibly small. It is also a point of great interest

and importance that in the region outside this boundary layer, the simpler equations of potential motion very closely apply, so that the effect of viscosity may be viewed as resulting in a virtual change in the geometrical form of the body, consequent upon the addition of this boundary layer, and within which the special phenomena of viscosity are manifest, while outside and beyond, the simpler conditions of potential motion prevail, at least in paramount degree.

In addition to the drag or resistance due to the energy drained away in this surface blanket of eddying turbulent fluid, and notably when the form of the body is rough and with abrupt curvatures or changes in the direction of the surface, there will develop large vortices breaking off irregularly and streaming to the rear, forming a wake of mixed turbulence, which again entails a draft of energy appearing likewise in the sense of a resistance to the motion.

The chief features upon which the phenomena due to viscosity seem to depend are as follows: (1) The character of the fluid; (2) the geometrical form of the body; (3) the character of its surface; (4) the relative velocity of motion.

Too little is known of the exact character and mode of action of the molecular forces producing rotation to permit of the formation of any wholly rational theory of the phenomena of viscous flow. However, here as elsewhere, guided by observation, hypotheses are possible which, developed through the aid of suitable mathematical procedures, are able to give a reasonably satisfactory account of the principal features of such motion.

Further refinement is to be expected and will doubtless be realized, but it hardly seems possible that we can ever rise above the need of following this general plan of attack. That is, it hardly seems possible that we can expect any refinement of theory which will enable us to follow in detail the adventures of any individual particle of the fluid in cases of viscous flow or, even were this possible, to treat other than in some general statistical manner the results in the aggregate for any given case.

These developments mark in a special way the advances made during the past half century in this part of the general field of fluid mechanics. No attempt will be made to discuss in detail the contributions made individually by the various pioneers in this field, but the names of Stokes, Navier, Osborne Reynolds, Rayleigh, Lamb, Prandtl, Blasius, Oseen, Pohlhausen, Karman and Levi-Civita may be mentioned among those who have made notable contributions to the development of the present status of the mechanics of viscous fluids.

Returning now to the problems of lift and resistance, and in particular for the case of the airplane, it results from the basic theory, as applied to the case of abruptly accelerated motion (as at the start of the plane), combined with the influence of viscosity and surface friction, that the initial circulatory motion about the airplane is generated. The existence of such a circulation about the plane has furthermore been demonstrated by clever photographic technique, and measurements on such photographs show that such motion, constituting the circulation referred to at an earlier point, fulfil in close degree the characteristics assumed by Kutta and Joukowski for the circulation in a perfect fluid.

With reference to the terms "circulation" and "circulatory motion," a caution should be noted that we are not to suppose a form of motion in which any given particle makes a circuit about the plane. The facts are rather that at any given instant particles will be moving in paths which form parts of such circulatory paths and, in theory at least, a continuous series of such particles could be found which collectively would form a continuous path about the plane. The circulation is therefore statistical or collective in character rather than actual for any one particle. This form of motion, however, meets perfectly the conditions as assumed by Kutta and Joukowski in their development of an explanation of lift, and the resultant formula measuring its value has been abundantly verified experimentally, especially with airplane wing forms.

It may naturally be asked how it comes about that a formula derived to fit the case of a non-viscous or perfect fluid should give so satisfactory a measure of conditions in actual fluids which are far from meeting the assumption of viscosity zero.

Without tarrying too long over this interesting point, it must suffice to say that in primary degree this result arises from the fact that in the outlying fluid, as noted at an earlier point, the motion of an actual fluid such as air or water very closely follows the laws which govern in the case of the non-viscous fluid. In other words, the immediate effects of viscosity and friction are confined to a relatively thin layer of fluid surrounding the body, and, outside of this, the laws for a non-viscous fluid largely govern the resulting fluid movement. It thus follows that the circulation taken in the fluid well outside the boundary layer will have closely the same value in an actual fluid as for the ideal fluid and hence the close agreement of the Kutta-Joukowski formula with actual measurement.

There is, however, one link in the chain of complete control over the phenomena of lift which yet remains to be filled in. The formula gives the lift in terms of the density, the velocity and the circulation. But there is as yet no general way of determining the cir-

culation having given simply the geometrical form of the body. By means of special assumptions, results can be derived for a certain range of geometrical forms, and these together with experimental results have given a very satisfactory working basis for forms of usual type. There is still lacking, however, the formulation of a general relation between geometrical form and circulation.

Passing now to resistance and its measure, we find a much more complex situation, which has been put on a reasonably satisfactory basis only in relatively recent years.

In the present status of this problem, three types or forms of resistance are recognized—frictional resistance, form resistance and induced resistance. In aeronautic terminology the word "resistance" is replaced by "drag," implying the resistance in the direct line of motion. In the fluid mechanics of the last century, the term resistance was sometimes used in the sense of the total force reaction between the body and the fluid. In more recent times and especially in aeronautics, this total force reaction is decomposed into its two components, at right angles to and along the line of motion, the former called lift and the latter drag.

Of the three types or forms of drag mentioned, that due to friction or skin resistance, so called, finds its explanation, as already noted, in the need for constantly supplying the energy required to maintain the eddying turbulent boundary layer.

The second type, from drag or resistance, finds a similar explanation in the energy drained away in the large vortex and mixed turbulence forming a wake in the case of bodies of irregular or non-stream line form. With well-formed airplane wings, this form of drag is small. Irregular projections or blunt forms, such as found in the wheels of the landing gear, contribute to resistances of this type.

The existence of the third form of resistance, the "induced" drag, was never suspected until relatively recent years, and its measure is a direct result of our better understanding of the details of vortex motion and of the types of vortex or cyclic motion generated by the passage of a body through a fluid.

Without attempting detailed discussion of this interesting point, it must suffice to say that as a result of the mutual reactions between a body such as an airplane wing and the air through which it passes, there is developed a system of vortex filaments trailing from the wing, the reaction of which upon the air flowing to and past the wing is such that the effective direction of flow is no longer in the direction of flight, but becomes inclined from the front downward to the rear. But the "lift," so called, must always be reckoned at right angles to the direction of relative air movement, and this direction will thus be inclined backward or to the rear. This means that the so-called lift force will have a component directed to the rear against the direction of motion, thus constituting a component of the resistance or drag. Our knowledge of the character and magnitude of these vortex filaments further permits of the derivation of very satisfactory formulae for the measurement of this component of the drag.

We may, therefore, sum the situation regarding resistance or at least drag, as involved in the problems of aeronautics, as follows:

The first component, that due to friction, has been placed, through extended experimental research, on a reasonably satisfactory basis.

The second component, that due to form and expressed in a wake of mixed turbulence, is of small importance in well-formed bodies of so-called stream line shape, such as an airplane wing of an airship of typical form—at least so long as the direction of motion is nearly fore and aft along the form. With increasing obliquity of approach, however, this component becomes of rapidly increasing importance. Here, likewise, experimental research has furnished a reasonably satisfactory foundation for estimating the measure of this resistance or drag, at least in such cases as are most likely to present themselves in practical problems.

The third form, the induced drag, as already noted, is satisfactorily subject to measure by means of formulae derived from the theory of vortex motion.

We must not leave the subject of these spectacular advances in the aeronautic applications of the theory of fluid mechanics without at least a mention of some of the names which have made such progress possible. The names of Kutta and of Joukowski have already been noted in connection with the formula for lift.

The dawn of the new vision of the behavior of an airplane wing or indeed of any body of similar form moving through the air goes back to the closing years of the last century when Lanchester came forward with his remarkable physical insight and gave the first picture of the phenomena attendant on such motion substantially in the form in which they are accepted to-day. This work dated from 1891, and in the following years and notably in 1894 he made his first public statement of these new views. These were extended somewhat in later years, but the basic ideas remained unchanged. Lanchester's work was essentially descriptive in character. He was not a formal mathematician and he did not attempt to develop in mathematical form the consequences of his physical picture. This was reserved for Prandtl and those who worked with him. These developments date from 1904 and, during the following years, though

unacquainted with Lanchester's work, large advances were made in expressing much of Lanchester's picture in mathematical form. At a later time Prandtl became acquainted with Lanchester's work and recognized its priority in time to his own, calling attention, however, to the need of quantitative expression such as that which he and his coworkers had sought to supply.

The work of Prandtl and of what may be called his school thus stands as the great achievement of the present century in the extension of our understanding of the phenomena of fluid motion and in the development of this understanding in mathematical form, thus serving to give a quantitative measure to many of the chief features of this complex picture.

We turn now and finally to a brief consideration of the influence of compressibility, the second point of difference between the perfect fluid and actual fluids in nature.

The effect of compressibility is of gradually increasing importance with increasing speed. It affects chiefly the magnitude and distribution of the force reactions between a fluid and a solid body, between which there is relative motion. The general criterion of velocity in these respects is that of sound in the fluid medium. For velocities not exceeding one half that of sound in the medium, the fluid is only slightly compressed by the force reactions developed, and for most practical purposes this effect can be neglected. As the relative velocity rises, however, approaching the velocity of sound in the medium, this effect rapidly increases in magnitude and at velocities near and beyond the velocity of sound, all force reactions undergo large increase, and these effects can be no longer discarded.

In air, if the velocity of sound be taken at 1,100 feet per second, this is equivalent to 750 miles per hour, and the more common modes of translation, whether by railroad train, automobile or airplane, will be so far removed from this figure that for such cases the fact of the compressibility of air has no significant influence on the attendant phenomena. On the other hand, in the case of an airplane propeller 9 feet in diameter and turning 2,400 revolutions per minute, for example, the speed at the tip of the blade will be about 1,130 feet and under these conditions the fact of compressibility becomes of importance and can no longer be neglected. The same is true in a still more emphatic manner when dealing with the problems of exterior ballistics. The velocities of projectiles fired from heavy guns are now rising to initial values of 3,000 feet per second and above, and for all such cases the compressibility of the air and its influence on the attendant phenomena will be of the highest importance. The same conditions will also be of controlling importance in all problems connected with the flow of compressible fluids in long-closed conduits, as, for example, the flow of natural gas over long distances, accompanied with a continually reducing pressure and corresponding change of volume.

The general equations for cases of flow or of relative motion with compressible fluids have been pretty well developed as a phase of what may be called the classical period and represented in particular by the work of the last century. These developments have been refined and extended somewhat in the years of the present century, and in their present form represent a reasonably satisfactory stage of advancement so far as abstract theory is concerned.

Practical applications, however, are still hampered by the difficulties met with in attempting to include the geometry of the form of the solid body with which the fluid is in contact, and also the effects arising from viscosity and skin friction. It results that, for practical problems, recourse must be had to experimental results and to various partial and empirical hypotheses, so adjusted as to represent the best information available at the moment.

It will thus be realized that while theory has gone far in explaining the phenomena of fluid mechanics and has provided useful and reasonably accurate formulae for certain portions of the force reaction, it is far from having furnished such formulae in an entirely general form, and for many of the features of interest in a quantitative sense, formulae are quite lacking. It may be noted that one of the principal difficulties in generalizing the formulae of fluid mechanics lies in the fact that we have no adequate method for connecting the geometry of form of a solid body with the phenomena to be anticipated in the case of relative motion between such a body and actual fluids, exhibiting, as they do, both viscosity and compressibility. A second difficulty, and perhaps the more serious of the two, is found in our lack of knowledge of what goes on in the interior of an actual fluid moving near or under the influence of a solid body. The mechanism of the development of minute vortices; their laws of growth or change, the establishment of mixed turbulence—of all these we have only the most sketchy knowledge in matters of detail. In consequence, our quantitative control over such phenomena must be primarily empirical in character or based on theory admittedly incomplete and inadequate.

Further extension of our knowledge of these details and a wider generalization of our mathematical control over these two major types of present-day limitation present an inviting field for further study in the years to come.

THE SEVENTEENTH ANNUAL MEETING OF THE PACIFIC DIVISION OF THE AMERICAN ASSOCIATION. II

By Dr. J. MURRAY LUCK
SECRETARY, STANFORD UNIVERSITY

ASTRONOMICAL SOCIETY OF THE PACIFIC

(*Report by A. H. Joy*)

Thursday, June 14, was devoted to contributed papers. In the morning session twelve were presented. In the absence of the president, Dr. E. P. Hubble, Dr. R. G. Aitken served as chairman. An attendance of twenty included representatives of nearly all the astronomical centers of the coast.

In the afternoon a joint session with the Physical Society was held under the chairmanship of Professor Orin Tugman, of the University of Utah. Four invited papers were read as follows:

Photographic studies of the planets in light of different wave-length: DR. W. H. WRIGHT.

Spectra of Venus, Mars, Jupiter and Saturn under high dispersion: DR. T. DUNHAM, JR.

Molecular spectra in the photographic infra-red: DR. D. M. DENNISON and A. ADEL.

Radioactivity and the age of meteorites: R. D. EVANS.

THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, PACIFIC DIVISION, AND THE BOTANICAL SOCIETY OF AMERICA, PACIFIC SECTION

(*Report by Geo. R. Hill*)

The Pacific Section of the Botanical Society of America and the American Phytopathological Society, Pacific Division, met conjointly. Dr. E. P. Meinecke presided at the first session.

Papers were presented as follows:

An automatic apparatus for the continuous measurement of carbon-dioxide absorption or evolution by plants under laboratory and field conditions: M. D. THOMAS.

The effect of vitamins on the growth of fungi in pure culture: DR. W. G. SOLHEIM, S. S. SEARS and R. C. ROLLINS.

Rainfall and the annual growth of Pinus ponderosa in the Roosevelt National Forest, Colorado: DR. ARTHUR D. MOINAT (read by Marion C. Harris).

Some factors governing root formation: W. F. WENT.

Physiological variations in pineapple fruits and their importance in the quality of the fresh and canned product: DR. C. P. SIDERIS and B. H. KRAUSS.

The inhibition of development of lateral buds by the growth hormone: FOLKE SKOOG and KENNETH V. THIMANN.

Studies of Nicotiana sp. inoculated with tomato streak viruses: M. SHAPOVALOV.

On the preparation and properties of the plant-growth hormone: KENNETH V. THIMANN.

An analysis of a few of the factors involved in the growth of plant cells: JAMES BONNER.

Life zones of Galapagos Islands: JOHN T. HOWELL.

Variation in Castilleja: ALICE EASTWOOD.

Some results in experimental taxonomy on California native plants: DR. CARL B. WOLF.

Some representative plant communities of Bridger Basin: LEO A. HANNA.

Some ecological aspects of uncontrolled grazing of the winter ranges in the Great Basin: DR. GEO. STEWART.

Studies on Psyllid Yellows of tomato: DR. H. L. BLOOD, Utah Agricultural Experiment Station, Logan, Utah.

Infective principle in Psyllid Yellows: DR. B. L. RICHARDS.

Some inoculation experiments with Dothiorella: C. O. SMITH.

Some biochemical changes accompanying Curly Top of tomato: DR. F. B. WANN, Utah State Agricultural College, Logan, Utah.

Sclerocystosis of Valencia orange fruits: DR. E. T. BARTHOLOMEW, Citrus Experiment Station, Riverside, California.

The Dieback form of tomato streak: M. SHAPOVALOV, Citrus Experiment Station, Riverside, California.

Some improvements in auto-irrigator apparatus: L. A. RICHARDS and H. L. BLOOD, Utah Experiment Station, Logan, Utah.

At the business meeting of the Botanical Society of America, Dr. W. A. Setchell, of the University of California, was elected *president* and R. M. Holman, of the University of California, was elected *secretary* for the year 1933–34.

The Thursday morning meeting was presided over by H. E. Morris, president of the Pacific Division of the American Phytopathological Society.

SOCIETY FOR EXPERIMENTAL BIOLOGY AND MEDICINE, PACIFIC COAST BRANCH

(*Report by Dr. M. L. Tainter, Secretary*)

The Pacific Coast Branch of the Society for Experimental Biology and Medicine met on Thursday morning with about thirty in attendance. In the absence of the Chairman, Dr. C. L. A. Schmidt, Dr. J. Murray Luck presided.

Professor C. C. Johnson opened the meeting with a demonstration of newly developed apparatus used in teaching in the Medical School of the University of Utah. He showed a new and inexpensive form of a spring-driven kymograph designed especially for recording skeletal muscle twitches, an arrangement

for recording simultaneously responses of six excised muscle strips, a circular saw for exposing turtle hearts, and a new type kymograph paper which lent itself to rapid copying of the record by the blueprint method. Dr. C. M. Blumenfeld discussed the ever-increasing difficulties in the field of scientific bibliography, arising from the tremendous number of journals and articles. He suggested that a solution of the difficulty, in making available all this scientific material, might be found in the establishment of central abstracting and collating bureaus. Dr. J. Murray Luck and W. Van Winkle, Jr., reported experiments on the differential inactivation of insulin by iodine. They observed that by treatment with iodine in buffered solutions, insulin could be inactivated with respect to its effects on blood sugar, inorganic phosphate and amino-acid nitrogen, differentially. The pH of the solution and concentration of iodine controlled the degree to which each of these properties was diminished. C. E. ZoBell and E. C. Allen discussed the attachment of marine bacteria to submerged slides. They observed when glass slides were immersed in the sea one to seven days, that bacteria, diatoms and actinomycetes attached before the barnacles, hydroids, Bryozoa, etc. Pure cultures of marine bacteria could be classified according to their ability to fasten to the slides. Dr. M. L. Tainter reported on the actions of α-dinitrophenol. He stated that the drug has the power of increasing metabolism in man and the common laboratory animals by acting directly on the tissues. The rise of metabolism may have many important clinical applications, as in the treatment of obesity, hypothyroid states, etc. Dr. D. A. Wood discussed his experiments on chronic thallium poisoning. Using the maximum doses of thallium, which did not produce acute death, he was unable to induce any important changes in the kidneys, bone or other organs, observable grossly or microscopically. Especially interesting was the failure to produce leukoplakia or other changes in the esophagus. R. A. Escobar and Dr. F. M. Baldwin reported experiments bearing on the longevity of various types of cells in the body and their probable rate of growth. Techniques were described whereby the rate of formation or length of life of blood cells, skin and digestive epithelium, etc., could be studied. The results indicated a much more rapid replacement of these cells than is commonly held. Dr. M. Kleiber and Professor J. E. Dougherty presented their experiments on the growth of baby chicks. Growth was fastest and the food consumption was highest at low temperatures. The amount of food eaten was found to be a linear function of the temperature. The highest degree of utilization of food was found to be at an environmental temperature of 100° F.

Utah Academy of Sciences

(Report by Dr. Vasco M. Tanner)

The twenty-sixth annual meeting of the Utah Academy of Sciences was held on Monday, June 12. President Dr. Bert L. Richards presided. Eight papers were presented at the morning session. The first was by Dr. John T. Wahlquist, University of Utah, on "Examination Systems in American Colleges and Universities." He concluded that "the Honor System is more common in private colleges than in public universities. More institutions have used and abandoned the Honor System than are now using it. It seems to succeed best in small, compact professional schools or in private colleges where it has the support of tradition. The most frequent cause of failure is lack of student cooperation." W. Preston Thomas, Utah State College, reported the results of a study on "Some Economic Factors Affecting Farm Incomes in Utah." Dr. Albert B. Reagan, Office of Indian Affairs, Ouray, Utah, presented two papers, "The Caves of the Vernal District of Northern Utah," and "The Grand Medicine Society of the Bois Fort Indians and Andy Fields Anakomigenung's Birch Bark, Medicine Lodge Parchment." Dr. Reagan concluded that the caves of the Vernal district had been inhabited by the people of the ancient Fremont stage and by the Basket Makers tribes. An interesting report on "The Effect of Spaying on Body Growth and Organ Weights of the Albino Rat" was made by Dr. Clay B. Freudenberger and Oscar Billeter, of the University of Utah Medical School. It was found that there were "no differences between the spayed and control rats in the following organs: brain, spinal cord, eyeballs, liver, spleen, kidneys, thyroid gland and hypophysis"; on the other hand, the "uterus of the controls weighed 19 times as much as the uterus of the spayed rats. The uterus apparently ceased to develop as soon as the ovaries were removed." Dr. F. B. Wann, Utah State College, made a report on "Preliminary Biochemical Studies of Psyllid Yellows of Potato." A report on "The Chemical Analysis of Utah Lake Waters Made during the Winter and Spring of 1933," was made by L. B. Decker, of the Brigham Young University, Provo. It was found that "the water of Utah Lake is not increasing in dissolved solids. The water is distinctly alkaline, has a high turbidity of extreme fineness and supports very little water grass or plant life," and that "the alkali salts in the water of the lake make it fair for irrigation purposes." An interesting study, "Report on Laboratory Investigations of Feasibility of Freshening the Proposed Diked-off Portion of the Great Salt Lake," by R. A. Hart and N. E. McLachlan, was presented by Mr. Hart, who concluded that "neglect-

ing possible infiltration of underground water, a period of two years would be required to freshen the water in the reservoir, based on average supply."

The following 16 papers were presented at the next session before the Physical Sciences Section: "The Application of Microscopy to Drill Core Assays in Disseminated Copper Deposits," by Daniel Frobes and Professor A. L. Crawford, University of Utah; "Volcanism near Salt Lake City," by Dr. Hyrum Schneider, University of Utah; it was pointed out in this paper that "products of explosive volcanoes occur at three different localities, all within a radius of nine miles from Salt Lake City. The volcanoes from which these products came have not yet been found." The "Occurrence and Possible Economic Value of Diatomaceous Earth in Utah" was presented by Raymond Wimber and Professor A. L. Crawford, University of Utah. Professor Crawford reported that "fresh-water diatomite beds, up to a reported thickness of 40 feet, are found near the Utah-Nevada line." "A Progress Report on the Study of Physiographic Types in the State of Utah" was given by Walter R. Buss, of Brigham Young University. A rather complete bibliography of the writings on Utah geology have been studied and compiled by Mr. Buss. The titles of the remaining papers follow:

Flotation significance of microscopic particles of gold from various stages in ball mill grinding: FRANK NETICK and PROFESSOR A. L. CRAWFORD, University of Utah.

A study of factors affecting corrosion in crude still condensing lines at Utah oil refining plant: ORVILLE POLLY, Brigham Young University.

An application of microscopy for evaluating the gold in certain Utah placers: PROFESSOR A. L. CRAWFORD.

A microscopic study of certain placer gold from Gold Creek, Montana: AARON STARLIPER and PROFESSOR A. L. CRAWFORD.

A quantitative study of crustal shortening of a geosyncline during uplift: VARD H. JOHNSON, of Brigham Young University.

Determination of the coefficient of slip of carbon dioxide by the oil drop method: ROBERT A. CLARK.

An experimental determination of Ne for carbon dioxide by the method of Brownian movement: PAUL HUISH.

A measure of the Zeeman effect in the Sodium D lines: ERVINE F. SMITH.

A study of the formation stages of spark breakdown in carbon dioxide and ethyl chloride by means of the electro-optical shutter: WALDO G. HODSON.

A study of the acoustics of the Desert Theater near Thatcher, Arizona: GEORGE L. SHEPPARD.

Evaporation from free water surfaces: HENRY R. WATSON.

In the Biological Science Section the following papers were presented:

Influence of carbon-nitrogen ratios of organic matter on the rate of decomposition in soil: IMRI J. HUTCHINGS and DR. T. L. MARTIN, Brigham Young University.

The genus Salmo in Utah: SHELDON HAYES and DR. V. M. TANNER, Brigham Young University (two native species, *S. Utah* Suckley and *S. pleuriticus* Cope, are found in Utah).

Recovery in Psyllid Yellow plants: DR. BERT L. RICHARDS, Utah State College.

The effect of castration on the suprarenal glands of the albino rat: CHAS. M. BLUMENFELD, University of Utah.

Life tables for white Leghorn chickens in the state of Utah: GEORGE GARDNER and HUGH HURST.

Influence of decomposing organic matter with different carbon-nitrogen ratios on changes in the micro-flora of the soil: KARL A. MILLER and DR. T. L. MARTIN, Brigham Young University.

Fermentation of tomato fruit pulp, a control for bacterial cankers, Aplanobacter michiganense E.F.S.: DR. H. L. BLOOD, Utah State College.

Notes on some Utah Lepidoptera: OWEN DAVIS, Brigham Young University.

The following officers were elected for the year 1933–34: *President,* Dr. Lyman L. Daines, dean of the Medical School, University of Utah; *first vice-president,* Dr. Lowry Nelson, dean of College of Applied Sciences, Brigham Young University; *second vice-president,* Dr. O. W. Israelsen, professor of irrigation, Utah State College; *secretary-treasurer,* Dr. Vasco M. Tanner, professor of zoology and entomology, Brigham Young University. It was also proposed and passed that the membership of the academy be divided into five sections as follows: Social Sciences, Physical Sciences, Biological Sciences, Applied Sciences, Arts and Letters.

Dr. Lowry Nelson, chairman of the Resolutions Committee, reported that after a careful study extending over a year, it was thought advisable to change the constitution of the academy to allow for the extension of its activities, and that the name of the academy should be changed to that of "Utah Academy of Sciences, Arts and Letters." This was moved and carried.

WESTERN SOCIETY OF NATURALISTS

(*Report by Dr. B. M. Harrison, secretary pro tem*)

The session for the presentation of papers was held on the afternoon of June 13. A paper by Frank H. Grinnell, on "Recent Studies in Mineralogy and Geology of the Arizona Fossil Forest," recorded the excavation of many stumps which had become fossilized after having been weather worn. Under the title of "A Preliminary Study of the Growth and Development of the Deermice of the Genus *Peromyscus*," Dr. Arthur Svihla showed, by numerous measurements,

that various parts of the body do not grow at the same rate. All curves record a rapid rate of growth up to about the time of weaning, and then a decided slowing down. Dr. B. M. Harrison and Miss Bessie Nyi presented a paper on "The Embryological Development of the Lacrimal Gland of the Horse." It was reported that the anlagen appear in the 27 mm stage and in succeeding stages increase in number to a maximum of twenty-two, from which they decrease to thirteen, in the 13 cm embryo. Under the title of "Some Stages in the Development of the Glands of the Urethral Tract of the Horse Embryo," Dr. B. M. Harrison and L. A. Bavetta showed that Cowper's gland appears at the 4.4 cm stage, the prostate at 5.3 cm and the Glands of Littre at the 9.2 cm stage. Two reels of moving pictures of the bird life on Hat Island of Great Salt Lake were shown by C. G. Plummer. He estimated that 100,000 birds come to Hat Island each year.

Western Society of Soil Science

(*Report by J. C. Martin, secretary-elect*)

Two half-day sessions of the society were devoted to a symposium on soil moisture.

Dr. W. L. Powers' paper on the relation of confined air to movement of soil water was read. In laboratory studies using burettes, it was found that with a constant head of 5 cm the rate of wetting of sandy loam and silty clay loam soils where the base was open, was about twice that in closed columns. Dr. G. B. Bodman and Dr. N. E. Edlefsen reported on the result of field measurements of the permeability to water of a silt loam soil at Davis, California. Dr. N. E. Edlefsen discussed the meaning of dielectric constant of a material, calling attention to water having a value of about 80, whereas that of most materials in the soil is of the order of 4. Equipment developed for the measurement of the dielectric constant of moist soil was described. Measurements in the laboratory and in the field indicate the dielectric constant of a moist soil to be a linear function of the quantity of water present. L. A. Richards and Dr. H. L. Blood described certain improvements they have made in the construction of auto-irrigator apparatus to overcome the difficulty of preventing air leaks in prevailing types of two piece double-walled irrigator pots. Dr. F. J. Veihmeyer and Dr. A. H. Hendrickson report that the permanent wilting percentages obtained by growing sunflowers in small containers of soil prove to be a reliable measure of those observed with permanently wilted crops in the field. Dr. Willard Gardner discussed dynamical principles underlying the movement of soil moisture, pointing out that for the movement of moisture in unsaturated soils the potential function as well as the transmission constant depends upon the moisture content of the soil.

A round-table discussion of problems in soil moisture was led by Dr. F. S. Harris. M. D. Thomas introduced the discussion showing peculiar vapor-pressure moisture relationships in soils saturated with sodium.

One half day was spent in observing, under the guidance of M. D. Thomas, some of the soil profiles on the upper bench lands and the alkali soils near Salt Lake, including an early reclamation project.

The last half-day session was devoted to miscellaneous papers.

R. C. Cole made a progress report on methods of measuring soil structure. As soils are slaked in water, they quickly reach an equilibrium where the particles are somewhat stable and whose stability seems not to be affected by prolonged standing in water. Mechanical agitation of slaked soils causes a breaking up of the aggregates.

The following papers are reported by title, since no abstracts have been obtained:

Activity of replaceable bases in bentonite: D. S. JENNINGS, DEWITT SMITH and M. D. THOMAS.

Nitrogen losses on the dry lands of Utah: A. F. BRACKEN and DR. J. E. GREAVES.

Studies in organic decomposition in the soil: DR. T. L. MARTIN.

Soil moisture studies under dry farming: A. F. BRACKEN.

SCIENTIFIC EVENTS

SALARIES OF SCIENTIFIC MEN WORKING UNDER THE BRITISH GOVERNMENT[1]

THE restoration of the economy cuts in salaries made by county councils and other public bodies in Great Britain within the last six months raises the important question as to when the government proposes to follow suit. These cuts have inflicted considerable hardship on a large body of scientific workers in government employment, and they were always avowedly temporary in their incidence. The ten per cent. reductions have now been operative for two years, and in very many cases they were imposed on basic salaries that were in no way adequate considering the scientific attainments of the victims. Admittedly they were a breach of contract, and there is considerable force in the contention that the government is in honor bound to follow the example of

[1] From *Nature*.

municipal bodies, and to restore these cuts at the earliest possible moment. The country's financial position is very different now from what it was in October, 1931. The national finances have been stabilized. Successive conversion schemes have reduced the burden of debt charges. The estimated revenue from the new tariffs for the current year is £24,500,000. Moreover, during the current year the revenue has received a windfall of more than £8,000,000 from death duties on the estate of the late Sir John Ellerman alone.

Trade is improving, and the adverse balance of trade is smaller than it has been for some considerable time. Employment is improving, whilst unemployment is decreasing. New industries are being launched, such as coal hydrogenation, which will be productive of increased employment and revenue. These new industries are frequently the outcome of scientific research; and it is not too much for scientific workers to expect that the conditions under which they have labored during the past two years shall, at least, be restored to the level of 1931. Point is added to this expectation when it is borne in mind that the government from time to time creates fresh appointments of a non-scientific character which carry no such burdens as salary cuts. A whole batch of appointments has recently been created under the Milk Marketing Board, none of which appears to have salary cuts imposed—notably a general manager has been appointed to this board at a commencing salary of £5,000 rising to £7,000; that is to say, this general manager's salary is not subject to the cut which is imposed on the Prime Minister's, and will eventually be higher than the Prime Minister's basic salary. Then recently a fresh appointment was made at the post office, and there was no mention of the salary being subject to an economy cut. It is obvious that the time is ripe for reviewing the whole situation.

THE NINTH INTERNATIONAL CONGRESS OF PURE AND APPLIED CHEMISTRY AT MADRID

Industrial and Engineering Chemistry gives an account of plans for the scientific organization of the Ninth International Congress of Pure and Applied Chemistry which were discussed at a gathering of chemists of Spain and other countries held at the summer university of Santander from August 8 to 18. Most of these chemists were present as lecturers in the summer school. The others were invited to attend these lectures and join in the exchange of opinions upon the best method of assuring the success of the Madrid congress.

Those present and the countries they represented were: E. Biilmann (Denmark); G. Barger (England); F. Haber and R. Willstätter (Germany); C. Matignon and J. Gérard (France); N. Parravano (Italy); Fr. Fichter (Switzerland); E. Cohen (Holland); H. von Euler (Sweden); P. de B. Carneiro (Brazil), and A. Seidell (U. S. A.). The Spanish organizing committee and their collaborators included: H. Hauser, *president;* E. Moles, *secretary,* and J. A. de Artigas, E. Barrón, A. Campo, O. Fernandez, J. Giral, A. Madinaveita, F. Calvet, I. Ribas, C. del Fresno and A. Perez Vitoria.

The journal continues: The conditions under which the conferences were held were most delightful. The chemists were guests at the beautiful Palace of the Magdalena, the seat of the summer university of Santander, where every provision was made for their comfort and pleasure. Lectures were given by chemists of exceptional distinction, visits were made to the industries and points of interest in the surrounding region, and once each day there was a round table discussion of plans for the next International Congress of Chemistry.

The date of the congress early received attention. Although the Spanish committee pointed out the advantages of the month of June in regard to agreeable weather and greater facility in securing hotel, dormitory and meeting-place accommodations, practically every representative of the other European countries considered that a date in April, immediately following the Easter holidays, would permit a larger attendance of chemists from their respective countries. The Spanish committee immediately assented, and April 5 to 11, inclusive, was chosen as the date of the congress. The opening session will be held on April 5 at 11:30 A. M.; the ordinary sessions on April 6, 7, 9, 10 and 11, and the closing session on April 11. Sunday, April 8, will be set aside for excursions.

It was decided that a general lecture should be given on each of the five days devoted to the scientific program: two dealing with pure chemistry; two, with applied, and one, with a question of outstanding biological chemical importance. The choice of the particular subjects for these principal addresses was given most careful consideration and a decision will be reached and announced later. It is expected that these addresses, as well as the papers presented before the sectional meetings, will be printed and distributed in advance. Individual communications will, of course, be welcome, but in order to be placed on the final program they should be submitted prior to February 5, 1934. The committee plans, however, to make such thorough preparation in advance that little will be left to uncertainty.

The congress will also include the usual social and excursion features. On account of the exceptional artistic, architectural and historical richness of Spain, the excursions should be of unusual interest. It should

be remembered, however, that the period chosen for the congress is that of the greatest affluence of tourists to Spain. Hotel provision can only be satisfactorily arranged by reservations made well in advance. It is especially desirable, therefore, that American chemists who plan to attend forward their names as early as possible, preferably before February 15, 1934, to Professor E. Moles, Secretaria general, IXth Congreso Internácional de Quimica, S. Bernardo, 49, Madrid (8).

The year 1934 will be an especially advantageous one for American chemists to visit Europe. In addition to the Madrid congress, the Third International Congress of Agricultural Industries will be held in Paris the preceding week. This will be devoted particularly to such industries as sugar, fermentation and distillation, fertilizers, foods, tropical products, etc. The French Maison de la Chimie is nearing completion and its inauguration with appropriate conferences will take place in the early fall of 1934.

COORDINATING COMMITTEES OF THE RAILROADS AND THE SCIENCE ADVISORY BOARD

THE three regional coordinating committees of the railroads were asked on October 11 by Joseph B. Eastman, coordinator of transportation, to name a committee of railroad officers to cooperate with a similar group selected by the Science Advisory Board of the National Research Council to determine whether efficiency of the roads could be increased by further scientific research.

The Science Advisory Board was created by an executive order of President Roosevelt on July 31 to deal with specific problems in various organizations of the government. At Mr. Eastman's request it has selected the following to treat with the railroads.

Dr. F. B. Jewett, vice-president, American Telephone and Telegraph Company; president, Bell Telephone Laboratories, Inc., *chairman*.

Maurice Holland, director, Division of Engineering and Industrial Research, National Research Council, director.

Dr. C. F. Kettering, vice-president and director, General Motors Corporation; president, General Motors Research Corporation.

Dr. John Johnston, director of research, United States Steel Corporation.

Dr. Francis C. Frary, director of research, Aluminum Company of America.

Dr. E. K. Bolton, chemical director, E. I. du Pont de Nemours & Co.

Dr. Harold G. Moulton, president, Brookings Institution.

Professor D. C. Jackson, head of the Department of Electrical Engineering, Massachusetts Institute of Technology.

R. L. Lockwood, director, Section of Purchases, office of Federal Coordinator of Transportation.

Dr. Isaiah Bowman, chairman, National Research Council, *ex-officio* member.

Mr. Eastman made public a letter he had written to Dr. Karl A. Compton, chairman of the Science Advisory Board, in which he stated that the success of scientific research by industries led him to believe that much might be accomplished to avoid waste and preventable expense by the railroads.

Dr. Compton said the suggestion fell exactly in line with the results of a preliminary survey which had been made, and which led to the question whether the railroads were taking adequate advantage of the opportunities and methods of applied science.

In his communication to the regional coordinating committees of the railroads, Mr. Eastman said that the appointment of the committee by the Science Advisory Board furnished an "opportunity to put this question to the test under excellent auspices."

SECTION F OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION F and the American Society of Zoologists will hold sessions for the reading of papers on Thursday, Friday and Saturday, December 28, 29 and 30, 1933. Certain sessions will be devoted to the reading of papers, while others will be given over to demonstrations. All demonstrations and exhibits will be presented in the new Institute of Biology at Harvard University, where there are ample accommodations for such presentation. In addition to this exhibit the facilities of the laboratories and some of the research projects in progress will be demonstrated by the staff of the institute. An all-day program for Friday, December 29, is being arranged at the institute.

Papers may be presented in three ways: "Read," "Demonstration" and by "Title." Those who can present their papers by demonstration are urged to do so in order to reduce the number to be read. Since Section F will hold no separate sessions for the reading of papers, all contributed papers will appear in the program of the American Society of Zoologists.

A symposium on the development and growth of the nervous system, led by Dr. S. R. Detwiler, is planned for Thursday afternoon, December 28. Other speakers will be announced later.

The annual dinner open to all zoologists will be held on Friday evening, December 29, and will be followed immediately by the address of the vice-president of Section F, Dr. A. S. Pearse. The title of the address is "Ecological Segregation."

The business session of Section F will be held on Friday, December 29, at 2 P. M. immediately preceding the business session of the Society of Zoologists.

Hotel headquarters for both groups will be the Statler Hotel, Park Square at Arlington Street, Boston. All rooms have baths; single rooms, $3.50 up; double rooms, $5.00 up; double room with twin beds, $6.00 up. Reservations for rooms should be made early by members, directly with the hotel, and not through the secretaries or the local committee. Lists of other hotels will be published in an early issue of SCIENCE, in the preliminary announcement of the American Association for the Advancement of Science. It is expected that the usual arrangements for obtaining reduced railroad fares on the certificate plan will be made by the American Association for the Advancement of Science and announced in SCIENCE.

Members of Section F who desire to present papers should write at once to Dr. William H. Cole, Secretary, American Society of Zoologists, Rutgers University, New Brunswick, New Jersey, for transmission blanks, which are to be filled out and must accompany titles and abstracts. When completely filled out the transmission blank will give all the information needed by the secretary for placing the paper properly on the program and will indicate all the special facilities needed for the adequate presentation of the paper or the exhibit. All titles and abstracts must be in duplicate and must be in the office of the secretary not later than November 10, 1933. Titles received after this date can not be placed on the program, and titles unaccompanied by abstracts and transmission blanks will not be considered or accepted. The rules of the American Society of Zoologists will be followed in arranging the program and conducting the sessions: Members are limited to a maximum of 15 minutes which may be used to read papers or to introduce papers to be read by non-members.

Titles and abstracts should be sent as early as possible to the Secretary of the American Society of Zoologists (Dr. William H. Cole, Rutgers University, New Brunswick, New Jersey) rather than to the secretary of the section.

GEORGE R. LA RUE

UNIVERSITY OF MICHIGAN

RECENT DEATHS

DR. HERBERT E. SMITH, professor of chemistry and head of the medical school of Yale University from 1885 to 1910, died on October 9, at the age of seventy-six years.

DR. MARSHALL PERLEY CRAM, professor of chemistry and mineralogy and Josiah Little professor of natural science at Bowdoin College, died on October 10 at the age of fifty-one years.

DR. LEON S. MERRILL, dean of the College of Agriculture of the University of Maine, died on September 3.

FARLEY OSGOOD, electrical engineer, formerly vice-president and general manager of the Public Service Electric Company, Newark, New Jersey, died on October 6. He was fifty-nine years old. Mr. Osgood was president of the American Institute of Electrical Engineers in 1924–25 and was a well-known lecturer on electrical subjects.

DR. J. WALDO SMITH, consulting civil engineer, responsible for the construction of many engineering projects including the Catskill water supply system of New York City, died on October 14 at the age of seventy-two years.

THE death at the age of fifty-eight years is announced of Dr. Herbert Lapworth, the English engineer and geologist, who was a son of Professor Charles Lapworth.

SCIENTIFIC NOTES AND NEWS

THE University of Toronto on October 13 at a special convention held in connection with the reopening of the Royal Ontario Museum conferred on Dr. Charles Greeley Abbot, secretary of the Smithsonian Institution, the degree of doctor of laws.

THE honorary degree of doctor of laws was conferred on October 14 at a special convention of Notre Dame University, South Bend, Indiana, on Senator Guglielmo Marconi.

THE Sedgwick Memorial Medal of the American Public Health Association has been awarded to Dr. Milton J. Rosenau, professor of preventive medicine and hygiene at the Harvard Medical School.

DR. EVANDER F. KELLY, secretary of the American Pharmaceutical Association, received the Remington Medal awarded by the New York branch of the association at a meeting at Columbia University on October 12. The medal is given annually for distinguished work in the field of pharmacy.

DR. EBEN J. CAREY, who was recently appointed dean of the School of Medicine at Marquette University, and Dr. Chevalier Jackson, professor of bronchoscopy and esophagoscopy at the School of Medicine at Temple University, Philadelphia, were awarded the annual gold medals for research of the Radiological Society of North America at the recent meeting in Chicago. The award to Dr. Carey was in recognition of his x-ray study of bone growth and to Dr. Jackson for his work in removing foreign bodies from the trachea and lungs with the aid of x-rays.

The William Mackenzie Medal of the Royal Faculty of Physicians and Surgeons, Glasgow, was awarded on October 13 to Professor Jules Gonin, of Lausanne, in recognition of his valuable contributions to ophthalmology, especially those bearing on the treatment of detachment of the retina. Professor Gonin delivered the William Mackenzie Memorial Lecture on "The Evolution of Ideas Concerning Retinal Detachment within the Last Five Years."

Washington University plans to make the original apparatus used by Dr. Arthur H. Compton in his study of the Compton effect, which is still in use in the laboratory, the nucleus of a group of exhibits illustrating "classical experiments." They will be in the new physics building, for which two anonymous donors gave $700,000 this summer.

Dr. Frederick G. Novy, professor of bacteriology at the University of Michigan since 1891, has been appointed by the Board of Regents dean of the Medical School. Since 1930, when Dr. Hugh Cabot resigned this office to go to the University of Minnesota, the affairs of the Medical School have been administered by an executive committee of five members with Dr. Novy as chairman.

Fred J. Lewis, professor of civil engineering at Vanderbilt University, has been appointed dean of the School of Engineering.

Dr. A. G. Pohlman, formerly dean of the School of Medicine at the University of South Dakota, was recently appointed head of the department of anatomy at Creighton University, Nebraska.

Dr. Townes Randolph Leigh, head of the department of chemistry at the University of Florida, has been appointed dean of the College of Arts and Sciences. The College of Pharmacy, of which he was formerly dean, has been placed as a school under the administration of the College of Arts and Sciences.

Dr. John R. Murlin, professor of physiology and director of the department of vital economics at the University of Rochester, has been given a grant by the Committee on Scientific Research of the American Medical Association to investigate the effects of the male hormone on the energy metabolism of human subjects.

Dr. B. P. Gerasimovic, professor at the University of Kharkov, has been appointed director of the Pulkovo Observatory near Leningrad.

Dr. H. K. Graham Hodgson, honorary radiologist to King's College Hospital, London, has been appointed physician-in-charge of the new department of x-ray diagnosis at the Middlesex Hospital, the development of which has been made possible by a gift of £25,000 from W. H. Collins.

J. P. Bushe-Fox, inspector of ancient monuments for England, has been appointed chief inspector of ancient monuments in succession to Sir Charles Peers, who has retired on attaining the age limit.

Professor James Franck, formerly of the University of Göttingen, will be the joint guest of the departments of physics of Harvard University and the Massachusetts Institute of Technology during the month of December. Professor Hermann Otto Szasz, formerly of the University of Frankfurt, has arrived at the institute, where he will be visiting professor of mathematics during the coming year, working principally in collaboration with Professor Wiener.

Dr. Heinz Werner, formerly professor and head of the department of experimental and genetic psychology in the University of Hamburg, has been appointed lecturer in psychology at the University of Michigan. This appointment has been made possible through grants from the Emergency Committee in Aid of Displaced German Scholars and from the Rockefeller Foundation. Professor Werner, a native of Vienna, specializes in child psychology and the psychology of music and esthetics.

Professor Otto Stern, who resigned recently as the head of the Laboratory of Experimental Physics at the University of Hamburg, arrived in New York on October 9 on his way to take up his work at the University of Pittsburgh. He is accompanied by Professor J. Estermann, who for years has been his co-worker in Hamburg.

Professor Ludwig Halberstadter, cancer specialist, formerly with the University of Berlin, now in Palestine, has been appointed director of the Institute of Radiology connected with the hospital established in Jerusalem by Hadassah, the Women's Zionist Organization of America.

A group of Manchester citizens has raised a fund to offer a temporary home to dismissed German scholars and several research fellowships at the University of Manchester have been founded for the purpose. The appointments are in no case for more than two years, and they will involve no burden on the general funds of the university. The research fellows may help in the teaching, particularly of advanced students, but they are under no obligation to do so, and the field of employment open to British graduates will not be narrowed by their presence. The following appointments have so far been made: Mathematics, Dr. R. Barr, Halle; physics, Dr. Rudolf Peierls, Leipzig; physiology, Dr. Walther Deutsch, Dusseldorf; psychology, Professor David Katz, Rostock.

At the annual business meeting of the University of Virginia chapter of Sigma Xi on October 5 the following officers were elected: Dr. Carl C. Speidel, *pres-*

ident; Dr. J. W. Beams, *vice-president;* Dr. Edwin M. Betts, *secretary and treasurer.*

AT the last annual convocation of the American College of Dentists the following officers were elected for 1933–34: *President,* Bissell B. Palmer, New York; *Vice-president,* J. Ben Robinson, Baltimore; *Treasurer,* Harold S. Smith, Chicago; *Secretary,* Albert L. Midgley, Providence; *Assistant Secretary,* William J. Gies, New York; *Regent* (five years), John E. Gurley, San Francisco.

THE Silliman Memorial Lectures were opened at Yale University on October 11 by Dr. Hans Spemann, director of the Zoological Institute of the University of Freiburg. His general subject is "Embryology."

THE first lecture on the Smith-Reed-Russell series at the School of Medicine, George Washington University, was delivered by Professor George Barger, of the School of Medicine of Edinburgh, on October 3. Professor Barger spoke on "Ergot and Ergotism." On the afternoon of the same day he held a seminar on "Newer Developments Concerning Hormones."

DR. FRANK SCHLESINGER, director of the Yale Observatory, gave an address on October 17 before the Rittenhouse Astronomical Society, Philadelphia, on "The Prediction of Eclipses."

DR. MARSTON T. BOGERT, professor of organic chemistry at Columbia University, was the principal speaker at a meeting of the New England Association of Chemistry Teachers on October 14. His subject was "The Chemistry of Vitamin A."

DR. KIRTLEY F. MATHER, professor of geology at Harvard University, recently gave a lecture at Tufts College on "The Origin of Life from the Standpoint of the Geologist."

THE sixty-third annual meeting of the American Fisheries Association was held at the Ohio State University from September 18 to 20, under the presidency of Dr. H. S. Davis, of the Bureau of Fisheries.

DR. FRANK LAMSON-SCRIBNER has given to the University of Maine, of which he is an alumnus, a collection of over 600 pamphlets, bulletins and books, including several rare volumes. These are all related to agriculture, especially to botany. Many have historical value in addition to usefulness for class work.

TURNING in of $35,000 to the state's general fund from the accumulated surplus of the orthopedic hospital at the University of Wisconsin was approved by the executive committee of the university board of regents recently. The hospital is the only one of its kind in the state. The surplus in the hospital's revolving funds resulted despite recent decreases in its charges, and the regents decided that the money should be turned in to the state's general fund for use elsewhere in the state's service.

A GRADUATE HOUSE for graduate students has been opened at the Massachusetts Institute of Technology this fall. Seventy-six of the 475 graduate students at the institute are living in this house. These seventy-six come from forty different colleges and universities and include students from four foreign countries. Next year it is planned to increase the accommodations to care for about 200 men. The master is Dr. Avery Ashdown, of the department of chemistry, and the house committee consists of Richard Fossett (electrical engineering), David Langmuir (physics) and Henry Rahmel (electrical engineering).

PREVIOUS awards from the Elizabeth Thompson Science Fund have been reported in SCIENCE, March 15, 1932, and earlier. Since the last report the following awards have been made at the meeting of May 25, 1933: No. 315 to G. H. Smith, Indianapolis, Indiana, $64 to purchase a water immersion objective and paired compensating oculars for use in the microchemical study of the embryonic leaf; No. 316 to E. A. Culler, University of Illinois, $300 for the feeding and care of dogs to be used in experiments on the effects of x-rays and of the destruction of limited parts of the intra-cochlear sensitive tissue on auditory acuity; No. 317 to Herman Schlundt, University of Missouri, $300 to defray extra traveling expenses incurred by O. B. Muench, of Las Vegas, New Mexico, and J. E. Wildish, of Kansas City, in working in Dr. Schlundt's laboratory during the summer of 1933. Professor Wildish to study the ratio of protactinium to radium on thorium minerals; Dr. Muench to analyze a monazite for its freedom from uranium. The trustees of the Elizabeth Thompson Science Fund meet ordinarily during the last ten days of the months of February, May and November. Applications for grants should be sent well in advance of the meeting to the secretary of the fund, Dr. A. C. Redfield, 20 Divinity Ave., Cambridge, Massachusetts.

THE following courses of lectures have been arranged at the Franklin Institute, Philadelphia: October 18, Dr. V. K. Zworykin, engineering department, research division, RCA Victor Company, Camden, New Jersey, "Television"; October 26, Dr. Gustavus J. Esselen, president, Gustavus J. Esselen, Incorporated, chemical research and development, Boston, "Before Papyrus—Beyond Rayon"; November 9, Dr. Edward Sampson, professor of geology, Princeton University, "Mineral Commerce and International Commerce"; November 15, H. B. Meller, air pollution investigation, Mellon Institute of Industrial Research, "Clean Air an Achievable Asset"; November 23, "The Historic Franklin Institute," final meeting

in the old building, program reminiscent of history and service of the institute; December 7, Dr. Paul E. Sabine, director of acoustical research, Riverbank Laboratories, Geneva, Illinois, "Acoustics and Architecture"; December 14, S. W. Ferris, senior research chemist, The Atlantic Refining Company, Philadelphia, "Petroleum Refining by Means of Selective Solvents"; December 20, Dr. George S. Crampton, Graduate School of Medicine, University of Pennsylvania, "Ophthalmic Lenses with Special Reference to the Modern Type of Bifocals."

ON September 29, the new department of preventive medicine at the University of Bristol, England, was opened by the Minister of Health, Sir Hilton Young. The department is housed in Canynge Hall, and under an agreement between the university and the city the preventive medicine work of the city will be carried out by the department. The medical officer of health for the city, Dr. R. H. Parry, has been appointed honorary professor of preventive medicine in the university, and Dr. I. Walker Hall, formerly professor of pathology, is director of the new laboratory. Canynge Hall will also accommodate the department of pathology, with Dr. Hadfield as professor, and the departments of medicine, surgery and obstetrics.

THE office of the Iowa Geological Survey, of which Dr. George F. Kay is director, has been moved from the State Capitol at Des Moines to the geology building of the State University of Iowa at Iowa City, Iowa.

THE American College of Dentists has presented to Columbia University a fund of approximately $2,000 to provide secretarial assistance for Dr. William J. Gies, so that he may be enabled in 1933–34 to continue his work as editor of the *Journal of Dental Research* and as secretary of the International Association for Dental Research, and to cooperate with the American College of Dentists in the promotion of education and research in dentistry.

PROFESSOR C. H. BAXTER, of the Michigan College of Mining and Technology, Houghton, has been asked by the American Institute of Mining and Metallurgical Engineers to aid in providing the U. S. Geological Survey with nearly 400 topographical and civil engineers and geologists. The survey has been allotted funds by the administrator of the Federal Emergency Administration of Public Works to carry out activities in (1) topographic mapping, (2) stream gaging and construction engineering, (3) underground water survey and (4) conservation of natural resources by plugging or conditioning abandoned wells, protecting mine shafts and openings and suppressing coal fires. The personnel requirements for this work will be approximately: (1) Three hundred technical men competent to do topographic mapping, transit traverse and control and levelling. All these, however, will not be employed at once, since so many projects are in high mountainous areas where work can not be undertaken this late in the year because of early snows, and because many projects are in the northern part of the United States where it is difficult to work in the winter. The southern projects should be undertaken as soon as practicable and crews run all winter. (2) Sixty-seven engineers with construction experience and qualified to supervise and direct the building of structures. (3) Twenty geologists with experience on ground-water problems.

Museum News reports that the Newark Museum, New Jersey, is now planning a campaign to raise $20,000, needed in order to obtain a conditional grant of equal amount from the Carnegie Corporation of New York. On the success of this campaign depends the opening this year of the Educational Department of the museum, which it was decided to close on account of reduced city appropriations. This department has been supplying large quantities of material to the schools of the city. A year ago the city made cuts in its appropriations for all city-supported organizations, including the museum. The museum's original appropriation was $150,000. This was reduced last year to $100,000 and this year to $50,000. After the first allotment this year the city added $15,000 to the museum appropriation by taking it from the Public Library, so that the total museum appropriation is $65,000. If the museum can earn the grant by raising the added $20,000 it will be on about the same basis as it was last year.

DISCUSSION

MORE ABOUT THE SPIRAL HABIT

UNDER the title, "Twisted Trees and the Spiral Habit," I recently published[1] evidence of considerable variety indicating that spiral movement and development among organisms are expressions of a widespread tendency which is protoplasmic in origin. Barely had the manuscript left my hands than I realized that I had failed to carry that part of my discussion dealing with twisted trees to the individual wood cell rather than stopping at the cotton fiber. I had in mind at the time the work of Scarth.[2] Before taking this up, I should like to turn for a moment to other examples of the spiral habit which have been brought to my attention as a result of the first account,

[1] SCIENCE, January 13, 1933.

[2] *Trans. Roy. Soc. Can.*, Sec. V, 269, 1929.

In listing the articles which have appeared in SCIENCE on the twisting of tree trunks, I overlooked the one by Koehler,[3] in which he states with emphasis that twisted grain is not due to prevailing winds acting on asymmetrical crowns, because there is no evidence within the tree trunk that actual twisting took place after the wood was formed.

The twisting of vines and tendrils around their supports is common knowledge to all, but possibly it is not generally known that both may change their direction of twist several times between the base and the tip. The tropical liane Bauhinia may change its direction of twist six times within four feet, or within nine complete revolutions.

Mr. L. F. Brady, of Mesa, Arizona, has been kind enough to send me photographs showing twisting in the stems of the cactus, *Chamaecereus sylvestrii*. Out of twelve stems on a single plant, four show a clockwise twist, six a counter-clockwise twist and two are straight. In general, Brady says, the twist is to the right. *Echinocereus* also shows twisting of the stem. The spines of *Neomammillaria* are arranged in perfect spirals.

It is reasonable to see in the wedge shape of long cambium cells an explanation of the twisting of tree trunks. The slippage or sliding growth of cambium cells would bring about a spiral twist. But such development can not serve as an explanation of the twisting of individual cotton fibers or of the walls of a single bast cell. Also, as the spiral habit is equally characteristic of animals from the lowest to the highest, the ultimate cause, if there is a universal one, must be protoplasmic in character.

A brief reference[1] was made to the spiral nature of certain body organs (the gall duct) in man. My attention has since been called to the work of F. T. Lewis,[4] who, in an article on symmetry in plants and animals, presents evidence of a pronounced tendency among body organs in mammals to show a marked right or left twist. The cardiac loop in man rotates dextrally. Human viscera do likewise. (The primary loop of intestines may rotate sinistrally, but rarely so.) The coiled colon of the pig is dextrally wound through three or four complete revolutions. The trachea and esophagus show dextral rotation. There is a dextral spiral trend of muscle fibers throughout the digestive tube.

Returning now to the spiral character of wood elements, there is the work of Scarth,[2] already referred to and illustrated in Fig. 1. The figure is of a portion of a single wood cell showing part of the wall. The wall is built up of concentric layers (20 in number and about 0.5 μ thick). Each comprises a parallel

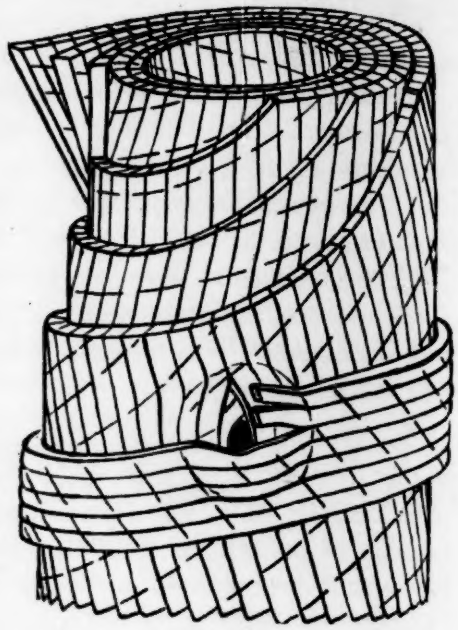

FIG. 1

series of fibers, the orientation of which varies from layer to layer. In the outer layers the fibrils are inclined at nearly 90° to the long axis of the fiber, in others at 0°–30°. (Fig. 1 is by Dr. Scarth.)

Herzog,[5] in a very interesting article on the structure of cellulose, gives evidence of the spiral wrapping of bast fibers. I had hoped to find in this article of Herzog's some suggestion of a molecular interpretation of the spiral orientation of structural units in natural cellulose, but no such suggestion is given. There is only a very cautious reference to crystals, which, from a solution that is slightly polluted, crystallize with a spiral structure. While we can not yet find in the molecule an ultimate explanation of the spiral structure of animate and inanimate things, we have at least some indication that molecules are, at times, also subjects of the same habit. There are molecules which show spiral (axial) symmetry (in the same way as do crystals), and molecules in which the atoms are arranged on a helical curve. The cellulose chain has a spiral axis of symmetry in that along the chain the rings are alternately right- and left-handed. The cellulose molecule, as ordinarily pictured, is linear. However, spirally wound molecules have been proposed for cellulose as fitting in well with some of their chemical characteristics, although this has been offered only as a speculation. The same can be said of the spiral molecule suggested for rubber.

Returning to less speculative and grosser, though still microscopic examples of the spiral habit, we have the newly discovered spiral structure of plant chromosomes. A spiral twist appears to be universally characteristic of plant chromosomes. It was first well established by Kaufmann.[6] Such a structure of plant

[3] SCIENCE, May 1, 1931.
[4] *American Naturalist*, 57, 1923.
[5] *Koll. Zeitschr.*, 61: 280, 1932.
[6] *Amer. Jour. Bot.*, 13: 59, 1926.

chromosomes is of particular interest in connection with the statement that the spiral habit is a heritable one. Chromosomes are thus carriers of a trait which they themselves possess.

Right- or left-handedness may be a more fundamental character than the spiral tendency and possibly responsible for the latter habit. Mirror writing, in which some children are adept, is an extreme form of left-handedness. Perhaps right- and left-handedness and the spiral habit are both expressions of a common, deep-seated and heritable protoplasmic quality.

There has just appeared an article by Haskins and Moore[7] in which they report the spiral twisting of two young citrus plants grown from irradiated (x-rayed) seed. Both plants showed marked twisting in a counter-clockwise direction during early life. After six months, the habit was abandoned and subsequent growth was normal. The plants gave other evidence of x-ray injury when young. Haskins and Moore conclude that the experimental conditions indicate that twisting was the result of a physiological rather than an environmental condition—possibly x-ray induced abnormal mitoses.

Crampton adds a further note to that already given[1] on the spiral coil of marine snails, which is usually dextral. It appears that where the one or the other mode of coil predominates, dextrality is a Mendelian dominant with reference to sinistrality, although the case is complicated by the fact that the mode of coil in snails is one of maternal inheritance.

Again we come to the conclusion that the spiral habit among organisms is of wide-spread occurrence and protoplasmic in origin. This statement does not preclude the possibility of the characteristic being suppressed, accentuated or otherwise modified by environmental influences.

After the manuscript to the preceding account had left my hands there appeared in Science two articles on the spiral habit, one by M. Copisarow[8] and one by E. J. Kohl.[9] The latter author takes up in detail the suggestion made above that the spiral grain in trees is due to slippage between long, wedge-shaped cambium cells, a hypothesis first brought to my attention by I. W. Bailey. I wish merely to add here that there can be no question as to the possibility from the point of view of structural mechanics, that spiral grain in trees is due to the gliding growth of cambium cells with oblique transverse walls. Certainly this type of structure must be a contributing factor to spiral growth in trees. But the explanation does not take care of the experiments of Haskins and Moore cited above nor of the spiral twist in cacti, and of course not of the many other examples of spiral development and movement in numerous and varied forms of organisms. The purpose of my first account[1] was to look further than the one instance of twisted tree trunks, and to recognize that there is throughout nature a very marked tendency toward spiral form and motion. Slippage of wedge-shaped cambium cells may be a correct explanation of twisting in trees (it may also be only the means by which a tendency toward spiral growth is able to manifest itself), but it does not take care of the several other forms of spiral structure in plants, the coiled thickenings of the walls of xylem vessels, the twist in bast and cotton fibers, etc. Each may have its own ultimate cause, but the habit is too wide-spread to preclude the strong possibility of a general tendency toward spiral form and movement in plants and animals. It seems, therefore, that the spiral habit, whether in trees, snails or chromosomes, is a fundamental heritable protoplasmic quality.

William Seifriz

University of Pennsylvania

[7] Science, March 7, 1933.
[8] Science, June 16, 1933.
[9] Science, July 21, 1933.

VEGETATION AND REPRODUCTION IN THE SOY-BEAN

General observations and considerable experimental work, recently summarized by Murneek,[1] point to the conclusion that the reproductive phase constitutes the most important limiting factor in the vegetative growth of plants. Where flowers are borne laterally (indeterminant type of growth) growth of the stem presumably continues until the developing fruits begin to monopolize the food supply. The data show an antagonism to exist between the vegetative and reproductive functions in fruit trees, tomatoes, cotton and some legumes. Maturity and death of some annual plants seem to be the direct results of heavy fruiting, since many of them will grow indefinitely and live for a number of years if fruiting is prevented. That this is not true for all plants has been proven by a series of experiments in our laboratories on soy-beans extending over a period of several years.

In the soy-bean vegetative growth stops at about the same time that the fruits begin to enlarge and the plant dies when the seeds are ripe. To all appearances the curtailment of growth is just another case of correlation between the vegetative and reproductive functions. However, removal of the flowers does not affect the growth of the soy-bean as it does that of many other plants. Exflorated plants stop growing at the same time as the normal control plants and become no larger either in height, diameter of

[1] A. E. Murneek, "Growth and Development as Influenced by Fruit and Seed Formation," *Plant Phys.*, 7: 79–90, 1932.

stems or size of leaves. The only visible difference is a darker green color and sometimes a slight wrinkling of the leaves. These exflorated plants remain green longer than the controls but do not grow and eventually drop their leaves and die.

Several changes accompany the development of fruits in the normal soy-bean plant. As the growth rate decreases, following the blooming stage, there is a very rapid increase in the percentage of dry weight, which means that the moisture content of the tissues diminishes. Accompanying this decrease in growth rate and loss of water is a very marked decrease in the percentages of potassium in all parts of the plant. Phosphorus also becomes less abundant in the stem tips than during the period of active growth. The percentages of nitrogen, however, show only slight decreases as the plant matures, although large amounts are used by the developing fruits.

Exflorated plants stop growing at the same time as the controls and the same changes occur in the chemical composition of the stems and leaves. This is a case of maturity which is not due to fruiting. The stems and leaves of exflorated and control plants are very similar in respect to moisture, nitrogen and mineral contents, although large quantities of nitrogen, phosphorus and potassium accumulate in the fruits. The only difference is that the exflorated plants show an abnormal storage of carbohydrates.

The soy-bean is a photoperiodic plant, and it is believed that the shortening of the day length not only initiates the reproductive phase but also curtails vegetative processes. It is significant that growth under normal seasonal conditions ceases simultaneously in exflorated and control plants and is accompanied in each case by decreases in the percentages of potassium and moisture. Also fruiting does not deplete the nitrogen or mineral reserves of the plant. Our comprehensive data show that old age and death in the soy-bean are due to circumstances which accompany the reproductive phase but are not the direct result of it.

Stanley Austin

Department of Botany
State University of Iowa

SOME SUGGESTIONS ON DEMONSTRATION

In the April number of *School Management* appeared a very well-executed summary of Professor Beauchamp's monograph, "Instruction in Science." This should provoke a great deal of thought in the thinking teacher and administrator. Almost every one of the four conclusions provides material for discussion. From the many things mentioned I select the following:

> Teacher-pupil demonstration has replaced the individual experimentation to a marked degree in the Junior high school. A great increase in the use of demonstration is also desirable in the specialized science courses. . . . This shift in emphasis has been accelerated by the use of the demonstration method.

These questions occurred to me: Did the teacher use specially designed instruments, specially adapted for demonstration? Was the demonstration table carefully designed for intelligent demonstration? Was the seating arrangement of the pupils such as to make the demonstrations clearly visible? Was the illumination of the demonstration desk of the best? Were the teachers trained specially in demonstration methods? Did supervisors or other superiors demonstrate to the teacher suitable examples for demonstration?

In looking over the apparatus purchasable at the various firms one must realize that the greater proportion of the instruments to be had there are designed for individual student use and not for demonstration purposes. The dimensions of the purchasable materials are all so small that they can not be seen at a distance. The type of experiments suggested in our present text-books also lack visibility, and it might be profitable to adopt the classical examples given by Helmholtz.

Having given considerable thought to the above, I took up in a General Science Class the subject of "the electric bell," employing the usual and accepted procedure. With a second class I adopted the following method and compared results:

Before reading the text-book about this subject I showed one of the films (through the courtesy of the Bell Telephone Company) which portrayed very clearly in animated pictures the action of the electric bell, the flow of the current, the changes of electromagnetism and the production of sound waves. This I followed up with a demonstration, using, however, a model of an electric bell 3 feet by 4 feet in dimension, constructed by some of my pupils for this express purpose. All parts of the electric bell were shown, and because of their large size could be seen clearly by every member of the class. The results were highly gratifying, and this procedure had the additional advantage of requiring no outlay of money for inadequate equipment.

The same idea was carried out in a demonstration of the steam engine. A cardboard model, showing all the moving and stationary parts of a steam engine, was used, also of the dimensions of 3 feet by 4 feet, and therefore also visible to every member of the class.

If the economic pressure of the times necessitates demonstrations rather than individual experiments, the designing of apparatus for such demonstrations should receive a thorough investigation, in which the

experience of teachers with vision and imagination should be of great assistance.

L. F. Pinkus

McKinley High School,
St. Louis, Missouri

AMERICAN BOTANY, 1886–1932, AS SHOWN IN THE BOTANICAL GAZETTE

A list of the principal articles published in the *Botanical Gazette* during the ten years 1886–1895 and a like list of articles for the decade 1923–1932 has just been compiled under my direction by Miss Lillian Bondurant, a graduate student. Titles have been classified in accordance with the scheme used by *Biological Abstracts,* but to save space in the tabular summary which I have made the subdivisions of physiology and systematic botany have been omitted. The average length of principal articles in the earlier period was about seven to nine pages and there were many short notes of less than a page, while the papers in more recent times are nearly twice as long. The pages of the ten volumes of the earlier period are 3,976, while the number in the last ten years is 8,866. Contributions in the recent period in every field, unless it be taxonomy, are of a far more technical nature than those in the early days of the *Gazette.*

TABLE I

Number of Principal Articles in the Botanical Gazette for Two Ten-Year Periods, Classified by Subjects

Subjects	1886–1895	1923–1932
Botany, general with also methods and apparatus	26	5
Bacteriology and immunology	10	10
Cytology	14	46
Ecology, including "natural history"	53	38
Evolution	4	0
Genetics	1	25
Morphology and anatomy of vascular plants	45	100
Paleobotany	4	17
Physiology, in all its branches	33	176
Phytopathology	16	21
Systematic botany, including morphology of the lower plants	176	82
	382	520

The nature of articles in certain fields has changed greatly; the early papers tabulated under ecology were more properly "natural history" and would hardly be recognized as belonging to ecology; the lone article recorded as genetics belongs better as evolution. A great increase has occurred in plant physiology, and many of its present subdivisions were almost if not entirely untreated forty years ago—as light relations, chemical relations, mineral nutrients, enzymes.

The changes in the *Botanical Gazette* are, it is true, not an exact measure of change in botanical literature during the period. In recent years many special journals have come into being dealing with particular branches of botanical science. These furnish an outlet for articles which formerly would have been offered to the *Botanical Gazette.* Yet the magazine continues to receive now, as it accepted in the past, contributions in all fields of botany, and it represents rather well, now as heretofore, the activities of American investigators.

It is interesting to read over the list of early contributors, among whom may be noted George F. Atkinson, Charles R. Barnes, Charles E. Bessey, John M. Coulter, W. R. Dudley, W. G. Farlow, George L. Goodale, Asa Gray, Byron D. Halsted, Theodor Holm, Conway MacMillan, Roland Thaxter and Lester F. Ward. It would be possible to make another interesting list of contributors of the earlier period who are still active in botanical investigation, but such a list would need to be a long one, if inclusive, while any selection of names might lead to invidious comparisons.

The compiled lists are typewritten, and when bound will be placed in the University of Colorado library, where they may be consulted.

Francis Ramaley

University of Colorado

THE FIRST AMERICAN LABORATORY OF PHYSIOLOGY

In the issue of Science for September 22, 1933, there was printed an obituary notice on Albert Martin Bleile, signed "F. A. H." In the notice it was stated that in 1876 "there was but one laboratory of experimental physiology in the United States, that of the late Professor H. Newell Martin, which had recently been established at the Johns Hopkins University." May I call attention to the fact that when Dr. Henry P. Bowditch returned from Ludwig's laboratory in 1871 he established a laboratory of experimental physiology in the Harvard Medical School. The apparatus in the laboratory was brought over from Germany at his expense. During the years between 1871 and 1876 Bowditch himself published papers on the lymph spaces in the fasciae, on a new form of induction apparatus, and on the force of ciliary motion. He and the late Charles S. Minot completed and published a research on the influence of anesthetics on the vasomotor centers. The late Dr. J. Ott published two papers, one on the action of lobelina on the circulation, and another on the physiological action of thebain. Experiments on the effect of bile in promoting the absorption of fat and observations

on intestinal digestion appeared under the names of Charles H. Williams and G. M. Garland, respectively.

Although Dr. Bowditch's laboratory was called a laboratory of physiology, it is obvious that it was hospitable to work on problems of pharmacology as well, even during the first years, 1871–76.

WALTER B. CANNON

HARVARD MEDICAL SCHOOL

SCIENTIFIC APPARATUS AND LABORATORY METHODS

GRASSHOPPER EGGS AND THE PARAFFIN METHOD

PETRUNKEVITCH,[1] in a recent issue of SCIENCE, has published formulae for several new fixatives, containing—among other ingredients—phenol or one of its derivatives. Phenol, he claims, gives "a peculiar elastic texture to the tissues, unlike anything produced by commonly used fixing fluids." It occurred to the present authors that such a fixative might be utilized in making sections of grasshopper eggs, a material which, hitherto, has proved extremely refractory to a paraffin technique. Following the ordinary methods of fixation, embedding, etc., the yolk is found to be hard and gritty, and sectioning becomes an impossibility. Freshly laid grasshopper eggs were, accordingly, fixed in the cupric-phenol solution (No. 1), as directed by Petrunkevitch. When eggs so treated were embedded in paraffin no difficulty was found in securing smooth, clean sections, providing that the surface of the block was wiped with a bit of damp filter paper immediately before cutting each section.

In order to test the value of such a solution for cytological purposes a grasshopper testis and a young grasshopper embryo were fixed with it. The results, however, were extremely unsatisfactory. Cytoplasmic details were badly distorted and the chromosomes were almost unrecognizable.

The idea then suggested itself that it might still be possible to secure the benefits of the new cupric-phenol mixture by allowing it to act after a fixative already known to be of value in chromosome studies had been employed. To this end grasshopper eggs were fixed over night in Bouin's solution. After a thorough washing in 70 per cent. alcohol these were placed in the Petrunkevitch mixture and allowed to remain there for approximately 24 hours. Eggs treated in this way were found to section in an entirely satisfactory manner.

In order to discover whether the second fixative could have any possible effect on cytological details, bits of grasshopper testis were fixed in Bouin's solution, then, after this had been washed out, treated with Petrunkevitch's mixture for periods varying from 2 hours to 4 days, sectioned and stained with Heidenhain's iron-haematoxylin. No difference could be detected between the chromosomes in such material and that prepared in the ordinary way.

As the next step Petrunkevitch's "Stock solution B" (consisting of 100 cc of 80 per cent. alcohol, 4 gm of phenol and 6 cc of ether) was used alone and found to be quite as efficacious as the entire mixture. It was likewise found that matters could be still further simplified by omitting the ether.

The procedure recommended at present, then, is as follows: Grasshopper eggs of the desired age are fixed in Carnoy-Lebrun, as suggested by McNabb.[2] These are washed in iodized alcohol, cut in half and the micropyle halves stored in 70 to 80 per cent. alcohol until needed. (Eggs which had been kept in alcohol for three months were found to be still amenable to the phenol treatment.) Exposure for 24 hours to 4 per cent. phenol in 80 per cent. alcohol is followed by dehydration in 95 per cent. alcohol. The eggs are then cleared in carbol-xylol, infiltrated with paraffin and each one blocked with the cut end out. The paraffin is trimmed away from the face of the block until the yolk is just exposed and the whole is then soaked in water for 24 to 48 hours. This last eliminates the tedious and time-consuming process of moistening each section separately and permits the egg to be cut as rapidly and as easily as any ordinary material.

As an alternative method the eggs, after fixation and exposure to the phenol solution, are dehydrated in 95 per cent. alcohol, cleared in anilin oil, washed in chloroform and embedded in paraffin, after which they are placed in water as before.

Preparations of various stages in the maturation and early cleavage of the eggs of *Melanophus differentialis* and *Chortophaga viridifasciata* have already been successfully obtained with the technique outlined above. Finally, it might be well to mention that Feulgen's stain, since it does not color the yolk, has been found an important aid in the study of such material.

The essential features of this process which differentiate it from those commonly employed consist of (1) treatment with phenol and (2) soaking in water. Either of these steps alone has been found insufficient; but the two combined give a perfect ribbon. It is not unlikely that other cytologists or embryologists dealing with objects which are difficult or impossible to handle with routine methods may find here a solution to their problems.

ELEANOR H. SLIFER
ROBERT L. KING

UNIVERSITY OF IOWA

[1] A. Petrunkevitch, SCIENCE, 77: 117, 1933.

[2] J. W. McNabb, *Jour. Morph. and Physiol.*, 45: 47, 1928.

SIMPLIFIED METHODS FOR MICRO-INCINERATION OF TISSUES

MICRO-INCINERATION of sections of isolated cells or tissues reveals with remarkable clarity the distribution of mineral ash in various parts of the cell. Various parts of the tissues are recognizable;[1] stages of mitosis can be traced;[2] the structural details of ciliates are found to be clearly represented.[3,4] It is a valuable cytological method and should be more widely used.

Many workers are undoubtedly deterred by the apparent need for special furnaces. A quartz tube furnace heated by gas or by electric coil, and with porcelain or platinum supports to prevent warping of the slide, has been recommended.[1,2] Emphasis has been placed on a relatively exact furnace temperature, for instance, 625°–630° C.,[5] and on careful shielding of the slides from dust by means of the quartz tube. The use of special quartz slides has also been recommended.[5]

We have experimented in this laboratory with simplified methods of ashing for cytological purposes. It was found[4] that an ordinary muffle furnace gave very good results. The temperature could be accurately regulated and the sections were effectively protected from dust by inverting Gooch crucibles over the slides. Using this method on *Paramecium,* the finest details could be made out: cilia, basal granules, differentiation between ectoplasm and endoplasm, etc.

Recently an even simpler method has been found to be entirely satisfactory. An ordinary hot-plate with exposed coils, which retails at about two dollars, was used instead of a furnace. The slides were set on the fire-clay rack holding the coils and covered with Gooch crucibles. The slides were incinerated at a dull red heat for about three to six hours. Sections of *Paramecium, Termopsis* and various rat tissues were incinerated with excellent results by this method. No trouble was experienced from warping of the slides when an ordinary hard-glass type was used. Shrinking and cracking of the sections is largely prevented by doing the initial heating slowly, taking two to three hours to bring the slide up to red heat. This may be done with a rheostat or by placing a heavy unglazed porcelain plate between the slide and the hot plate.

The whole procedure is as follows: Fix in formol-alcohol,[3] dehydrate, embed in paraffin, section and spread on a slide by the usual methods. Incinerate three to six hours (two to three hours initial heating, one half to three hours at red heat), cool and seal a cover slip in place with paraffin. Examine with a dark-field microscope, or, if that is not available, by oblique illumination against a black background.

This method is easier than many of the cytological methods commonly taught and does not need to involve any apparatus not found in the ordinary histological laboratory. The simplified micro-incineration method is splendidly adapted for routine laboratory use for class demonstration of the distribution of mineral ash in cells.

R. F. MACLENNAN

DEPARTMENT OF ZOOLOGY
STATE COLLEGE OF WASHINGTON

[1] A. Policard, *Protoplasma,* 7: 464, 1929.

[2] G. H. Scott, *Bull. d'Histol. Appl. Phys. et Path.,* 7: 251, 1930.

[3] E. S. Horning and G. H. Scott, *Jour. Morph.,* 54: 389, 1933.

[4] R. F. MacLennan and H. K. Murer, *Jour. Morph.,* (in press).

[5] E. S. Horning, *Jour. Cancer Research Comm.,* Univ. Sydney, 4: 118, 1932.

SPECIAL ARTICLES

DEMONSTRATION OF THE CENTRAL BODY IN THE LIVING CELL

IN recent publications, Wilson and Huettner[1] offered conclusive evidence, based on observations of fixed preparations, of the existence of central bodies in Drosophila eggs It is the purpose of the authors to add new evidence of the existence of central bodies based on living material. These findings were obtained in the course of studies, now in progress, on the pole cells of developing eggs of *Drosophila melanogaster.*

In making these studies, the method introduced by Child and Howland[2] for observing the living Drosophila egg was employed. The opaque, chitinous chorion was first removed with a sharp needle, leaving the naked egg with its shiny, transparent and tough vitelline membrane intact. The egg was then placed on a coverslip on which a thin layer of Ambroid cement had been previously spread and baked to complete dryness. Ambroid solvent (amyl acetate) was next applied on the ambroid near the egg in such quantity as to allow only a thin film of dissolved ambroid to spread under the egg. Since amyl acetate is a very volatile liquid, the ambroid under the egg dried in a short time, leaving the egg securely fastened to the coverslip. The egg was now surrounded by a drop of any desired medium and the coverslip was inverted, placed on a depression slide and sealed with vaseline.

Using this method, the living egg could be observed, with the aid of the microscope, under any desired magnification. Great care was taken that the egg should suffer no injury while being prepared for observation. Such injury could occur:

[1] SCIENCE, 73: 447–448, April 24, 1931, and *Zeitsch. f. Zellforsch. u. Mikr. Anat.,* Vol. 19, No. 1, 1933.

[2] SCIENCE, in press.

(1) In peeling the eggs. Repeated experience showed that an excellent criterion for judging the injured eggs was the presence of granules, in Brownian movement, within the micropyle. It was often found that, although there was no other apparent injury, when the micropyle contained granules the egg did not develop in a normal manner. On the other hand, when there was no visible injury and these granules were absent, the egg invariably developed normally.

(2) In the application of amyl acetate. Care was taken that the amyl acetate should not wash ambroid over the egg, for, on drying, a film of ambroid covering the egg would exert great pressure and thus injure it.

(3) By excessive desiccation. This was avoided by preparing the egg for observation very rapidly and by sealing the coverslip to the depression slide with vaseline. Another precaution that was taken was to place a drop of the medium on the bottom of the depression.

Only after proper orientation can the pole cells be observed to best advantage. Since they are more concentrated dorsally, the best view of them was obtained when the egg was placed with its dorsal (more or less concave) surface against the coverslip. The pole cells begin to bud off at the posterior end of the egg at the time of the 8th or 9th cleavage. As soon as they push off, they divide, so that by the time the egg is in the 11th cleavage, 10 to 12 pole cells are present. The pole cells are particularly advantageous for the observations of central bodies since they are large, since they are free from yolk spheres and since the surface of the nucleus of the pole cell is free of any extraneous granules which are found scattered through the cell.

With a magnification of 1,500 times, in many of the pole cells on the upper periphery of the pale, hyaline nucleus, two spherical bodies opposed to each other were observed. The distance between these bodies varied. When they were close together, they seemed to lie within a single vacuole. When they were some distance apart, each one appeared to be enclosed in its own smaller vacuole. (Wilson and Huettner[1] described such a small clear area about the central body, in fixed preparations, at the beginning of prophase). These bodies were identified as the central bodies by their behavior during division of the cell, by their position in the cell and by their distinctive appearance. They possessed a slight vibratory motion so that one could get both of them in focus at the same time for only a very short interval. The central bodies in each pair were of the same size. On the whole they seemed to be less transparent than the ordinary granules which are present in the cytoplasm of the pole cell.

The central bodies may also be identified near the nuclei of blastodermal cells. These cells are not as favorable for observation as the pole cells, since they are much smaller. Moreover, it is easy for one to confuse the central bodies with the mitochondria and other cell inclusions which swarm about the nuclei. For the same reason, the behavior of the central bodies, during cell division, can not be followed in the blastodermal cells.

During divisions of the pole cells the central bodies were seen to move apart along the periphery of the nucleus. This movement was gradual at first, but as the nucleus lengthened, they moved apart more rapidly. Although they were not actually seen to divide, shortly after this, the nucleus still being elongate, 2 pairs of central bodies were observed, one pair near each end of the nucleus. The central bodies of each pair kept shifting their positions with respect to each other. This accounts for certain conditions found in fixed preparations. For example, in telophases of the nuclear cleavages, at each end of the cleavage figure, the two pairs of central bodies are not placed similarly but may occupy any conceivable position with respect to each other.

The central bodies were observed best at the stage in the development of the egg where there are about 10 to 12 pole cells. At this time they are undergoing division and are not crowded to such an extent that they overlap each other. They were seen in the pole cells of eggs developing in various external media, namely, 33 per cent. sea water, 0.5 M. glycerine and pure egg albumin. In each medium, the eggs developed quite normally, *i.e.,* larvae hatched out in the normal length of time.

These observations, though they are of a preliminary nature, demonstrate that the central bodies have an actual existence in the living cell. They have a distinctive appearance and behavior in the pole cells of the normally developing egg of *Drosophila melanogaster*. One can also observe them in the cells of the blastoderm. They are not as obvious in these cells, however, for cell inclusions such as mitochondria, which are very numerous, fill the cells.

ALFRED F. HUETTNER
MORRIS RABINOWITZ
NEW YORK UNIVERSITY

A STUDY OF CANNED SHRIMP WITH REFERENCE TO THE PRESENCE OF VITAMINS A, B AND D

QUALITATIVE tests on wet-pack and dry-pack canned shrimp[1] show that vitamins A[2] and D are present in

[1] After shrimp are cooked and weighed into cans, wet-

shrimp fat, but that B is either absent or present in very small quantities. There was no evidence of any appreciable difference in the vitamin potency of the two kinds of shrimp.

The vitamin A determinations were made on 16 rats,[3] four receiving a normal diet,[4, 5, 6] twelve receiving an A-deficient diet.[7] At the end of the fifty-day depletion period all rats on the deficient diet showed a flattened growth curve (daily weighings plotted); all had scraggy, rough coats and eyelids showing extreme redness and varying degrees of incrustation. Shrimp fat[8] then was added to the diet of all but four of the A-deficient rats. These four rats were continued on the deficient diet to serve as negative controls. The worst of the group had snuffles and was almost blind; it was included in the group fed with shrimp fat, and while it made some improvement as to weight and eye condition, it died a few days after the curative feeding was begun. With this exception, every rat receiving shrimp fat (0.2–0.3 gm daily) began to show a sudden and continuous rise in the growth curve, the curve paralleling that of the rats on the normal diets. The general appearance improved and the eye condition healed. Of the negative control group, one died; one went blind in both eyes; one went blind in one eye; and one had eyes almost incrusted at the end of the test period. Vitamin A was considered to be present in the fatty extract of the canned shrimp, as evidenced by its effect on the growth curves of the A-deficient rats and its curative effect on ophthalmia.

pack shrimp are covered with a mild brine solution before sealing.

[2] Hjort, *Proc. Roy. Soc.*, London, B 93, 440, 1922, and Jansen and Donath, *Meded. Begerl. Geneesk. Dienst Nederland. Indie*, 46–48, 1924.

[3] The rats used in these experiments were obtained through the kindness of Dr. Henry Laurens and Dr. H. S. Mayerson, department of physiology, Tulane University, and were from the breeding stock which had been kept five years on a normal diet. They represent entire litters approximately 28 days old when taken from the mothers' cages.

[4] Casein, 20 parts; salt mixture,[5] 5 parts; butter, 15 parts; cornstarch, 60 parts.[6] Yeast and Viosterol were given daily.

[5] Osborne and Mendel, "Salt Mixture IV," *Jour. Biol. Chem.*, 37, 572, 1919.

[6] Jones, Murphy, Nelson, *Jour. Ind. and Eng. Chem.*, 20, 205, 1928.

[7] The A-deficient diet was the same as the normal, except that the casein was purified and Crisco was substituted for butter.

[8] Shrimp fat was made fresh every week or ten days. Six cans of shrimp—800 grams—were ground fine; allowed to stand 48 hours in contact with petroleum ether (b.p. below 50° C.); the ether expressed with pressure; the extract filtered and evaporated at room temperature before a fan. The extract was approximately 2 per cent. of the original weight and approximately 50 per cent. fat; but no further effort was made to purify the fat as it was thought that a minimum of handling would conserve the vitamin content.

In the vitamin B set-up, all rats were put on a B-deficient diet.[9] One half of the group received in addition the canned shrimp *ad libitum*. One half a shrimp, about 3.5 gm, was the average daily intake. Both groups showed increasing signs of B-deficiency; and when spastic paralysis of the hind quarters set in, the group that had been receiving shrimp had yeast added to the diet. All except one rat recovered, and it died a few hours after paralysis was noted. The group that had received no shrimp had shrimp added to the diet when paralysis was manifest. They ate avidly of it (8–10 gm daily), but no improvement followed. Vitamin B appears to be absent in shrimp or to be present in such small amounts that 3.5 gm did not protect the rats from peripheral neuritis and 8–10 gm exerted no beneficial effects.

The vitamin D group consisted of 16 rats, four on the normal diet, twelve on Steenbock's D-deficient diet.[10] All were x-rayed[11] after the depletion period. The four normals had no evidence of rickets; the twelve on the deficient diet were rachitic. Four rats were chosen to be continued on the rachitic diet, and these showed rickets throughout the test period. An attempt was made to feed whole shrimp as the source of vitamin D, but the rats would not average over a 1.4–4.1 gm daily intake; so at the end of ten days, shrimp fat which they relished was added to the D-deficient diet in amounts representing 10–15 gm canned shrimp (0.2–0.3 gm fatty extract). On the thirteenth day of this new feeding régime, the x-rays showed that the rachitic condition of five of the eight rats receiving shrimp fat was healed and the other three showed improvement. At the end of the next week, one of these three was healed, one almost healed, and the third not much improved over the condition of the previous week, but better than at the beginning of the shrimp-feeding period. The negative controls were still rachitic and the normals free from rickets. Vitamin D, as evidenced by the beneficial effect on bone calcification of the feeding of shrimp fat with an otherwise D-deficient diet, was judged to be present in canned shrimp.

The writers wish to acknowledge the helpful interest of Dr. A. O. Kastler, of the department of biochemistry, Tulane University.

Margaret C. Moore
Hal W. Moseley

Department of Chemistry
Tulane University

[9] The B-deficient diet was the same as the normal, except that no yeast was given.

[10] Steenbock and Black, *Jour. Biol. Chem.*, 64, 263; Nelson and Steenbock, *ibid.*, 64, 299, 1925.

[11] "The Quantitative Estimation of Vitamin D by Radiography," Medical Research Council, London, 1931. The radiography was done by Dr. J. N. Ané, department of roentgenology, Tulane University, School of Medicine.

TOMATOES, BERRIES AND OTHER CROPS UNDER CONTINUOUS LIGHT IN ALASKA

HAVING read of strawberry production in central Alaska under six weeks' continuous daylight in summers, and having seen illustrations in the Alaskan stations' reports of the remarkably vigorous growth of strawberries, the writer became interested in making tests of their growth under continuous artificial light (500 watts) and under a combination of artificial light at night and of daylight for the day periods. After five months (November 11 to April 9) the plants of the several species and varieties used had made a somewhat spindling growth under the continuous artificial light and were not as vigorous as those under the 24-hour combination of artificial light and normal daylight. However, the test did show that it was possible to grow strawberries under continuous artificial light, and with improvement in the intensity and other environmental conditions even more satisfactory growth could be expected.

Reports of experimental results in growing tomatoes under artificial illumination have indicated that they reached maximum development with the 12-hour daily light exposure, and were injured by daily light exposures of 17 or more hours.[1] A recent paper[2] reports that where light of the same composition as sunlight is reduced to 35 per cent. of full sunlight, tomatoes did best. This would indicate an illumination of 3,500-foot candles as optimum for tomatoes. Continuous illumination, using as low as 150-foot candles, injured tomato plants, but when half sunlight and half artificial light were used the rate of injury was greatly decreased.

Though these reports have simply meant to the writer that the laboratory conditions were not the same as out-of-door conditions, recent conversations with others have indicated that many have assumed that tomatoes would not grow vigorously under long days, under continuous light or under full sunlight. However, in the report of the Alaska Agricultural Experiment Stations for 1915 there is a photograph of remarkably vigorous plants growing out-of-doors at Fairbanks, Alaska (64°–0′), less than 2 degrees from the Arctic Circle, and the statement occurs (page 51):

> Twenty tomato plants were set in the open garden early in June. These plants bore from 6 to 10 pounds to the vine, and about 30 pounds ripened thoroughly on the vines.

In the report for 1916 a picture (p. 33) is shown of plants set June 1 out-of-doors at Rampart, Alaska (lat. 65°–30′), which produced ripe fruit August 1. In the report of the Agricultural Experiment Station for 1918 there is a photograph of Bonny Best tomatoes grown at Rampart, Alaska (lat. 65°–30′), and the statement is made (p. 50) that:

> In the greenhouse the plants bore remarkably well, producing many large handsome clusters, Bonny Best leading in this respect. The early part of the summer was too cold, however, for tomatoes to do well out-of-doors. Though most of the blossoms blighted, there was still considerable fruit, some of which ripened.

Other reports of the Alaska Stations both earlier and later contain other references to tomatoes in central Alaska where there is continuous daylight for about six weeks in midsummer from about the time the plants are set in the field until they have produced a heavy crop of fruit.

Director G. W. Gasser, of the Experiment Station at Fairbanks, has kindly sent me the figures on sunlight for that station. Fairbanks, Alaska, has 1,266.7 hours of sunlight out of a total of 1,464 hours during June and July (as compared with 900 hours of sunshine at Washington, D. C., for the same months). This leaves an average of about 3.2 hours per day for June and July at Fairbanks without sunlight, most of the 3.2 hours, however, being lighted and effective for plant growth.

Though the studies of Allard and of many others on the effects of the length of the daily light periods on plants have given us results of immeasurable and of immediate practical value, there is danger of drawing hasty generalizations concerning the effect of sunlight from the effects of artificial light under laboratory conditions.

Those making light studies with crop plants will be interested in the wealth of information in the Alaskan stations' reports on the response of many different vegetables, flowers and field crops in regions of extremely long days and of continuous light.

GEO. M. DARROW
BUREAU OF PLANT INDUSTRY
U. S. DEPARTMENT OF AGRICULTURE

[1] N. E. Pfeiffer, "Microchemical and Morphological Studies of Effect of Light on Plants." *Bot. Gaz.*, 81: 173–195, 1926.

[2] J. M. Arthur, *Torreya*, 32: 107–108, 1932.

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